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OF

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PALEONTOLOGY

Royal Society of Victoria.

NOTES ON THE LOWER TERTIARIES OF THE SOUTHERN PORTION OF THE MOORABOOL VALLEY.

(WITH PLATES.)

BY

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ART. III.—*Notes on the Lower Tertiaries of the Southern Portion of the Moorabool Valley.*

(With Plates III and IV.)

By T. S. HALL, M.A., and G. B. PRITCHARD.

[Read March 5, 1891.]

The occasion of the visit of the University Science Club to Geelong for their long-vacation trip enabled us to make some observations on the geology of this locality.

The course of the stream, from its sources to the eastward of Mount Warrenheip down to its junction with the Barwon at Fyansford, near Geelong, is across the eastern portion of the great volcanic plain of South Western Victoria. Like most of our streams flowing through basaltic country, it has cut a deep and narrow valley of its own, and has in many places exposed the underlying deposits. In the upper part of its course, these underlying deposits are of lower silurian age, while in its lower part they consist of tertiary strata.

Our observations dealt principally with the older tertiary deposits, and extended from the railway viaduct, near Batesford, down to the junction of the stream with the Barwon at Fyansford.

GRANITE.

The oldest rock exposed is the granite, an outcrop of which, about a square mile in extent, occurs at the Dog-rocks near Batesford. Another outcrop, a few yards in extent, occurs where the Maude Road crosses Sutherland's Creek at Darriwill, ten miles from Geelong; and probably granite occurs at no great depth beneath the surface everywhere between the Dog-rocks and the granite hills of the You Yangs.

LOWER TERTIARY.

Half a mile below the viaduct, on the left bank of the stream occurs a section which is noted as fossiliferous in the geological quarter-sheet. This section is marked (9) on the plan. Lately a small road cutting along its base has afforded easy means of better examination of the beds. The section is fairly typical of all that occur in the valley. The lower portion consists of a dark grey clay, containing a great deal of shelly matter. This becomes yellower as it passes upwards, and contains a slight admixture of sand. Concretionary masses of calcareous material make their appearance, and in places form compact irregular bands. Fossils, especially gastropods, are more plentiful at the base of the series, while in the upper part lamellibranchs, and also brachiopods occur, the gastropods being exceedingly rare. We record 122 species from this locality.

There is no doubt that the deposit represents but one series of beds. The passage from one kind of sediment to another is a gradual and not a sudden one. The beds merge into one another in such a way as to leave but little doubt that the process of sedimentation was continuous, and though certain fossils abound more in certain parts than in others, the difference is due to a variation in the sea bottom, due to different material being deposited, and to the depth at which the deposit took place, and not to a great difference in age, as the lamellibranchs and brachiopods of the upper beds occur also in the lower members of the series.

Near the Dog-rocks, the polyzoal limestone makes its appearance, and in one or two places forms low cliffs on the river bank. The beds when examined at a distance show a slight dip, which is approximately to the south east. We were, however, unable to measure its amount and direction accurately. The lowest beds exposed are at the upper quarry (see plan 8). The rock here is almost entirely made up of foraminifera, which lie at all inclinations to the bedding plane. A sample of the rock was forwarded to Professor Tate, and by him submitted to Mr. W. Howchin. This gentleman states that the great mass of the rock is made up of individuals of *Orbitoides mantelli*, and he suggests the name *Orbitoides limestone* for the formation. The other conspicuous genera, which however are relatively few in number, are *Amphistegina*, *Operculina*, and *Gypsina*. The rock is very friable and is quite distinct from the overlying

polyzoal limestone which, however, contains similar foraminifera freely scattered through it, though its great bulk consists of polyzoa and spines and plates of echinoderms, together with a few lamellibranch shells; 14 species are recorded from this locality.

The base of the section is hidden by the drift of the valley, but judging from the close proximity of the granite. it is of no great depth.

The hill section is as follows:—

Basalt	... ...	75 ft.
Incoherent sandy material, with calcareous concretions	... ...	50 „
Yellow clay, with calcareous concretions		5 „
Polyzoal limestone	... ...	25 „
Orbitoïdes limestone	... ...	20 „
Total	...	175 ft.

The change from the limestone to the yellow clay at this point is a sharp and not a gradual one. The grey clay which, as before mentioned, is so abundant in gastropoda, is absent, having thinned out towards the granite on the flanks of which the deposit rests.

The polyzoal limestone at the places marked (7) and (8) in plan is of a lighter tint than that of the well-known Waurn Ponds rock, being in places of a dazzling whiteness; but fossil evidence shows the two deposits are of the same age. We record 16 species from the filter quarries (see plan). Near Madden's (see plan 6) a cliff section shows the following interesting characters:—The polyzoal limestone forms the base of the cliff. This rock in its upper portion is in most places of a crystalline texture, and very few perfect shells are to be found in it, the fossils being represented principally by casts. A similar state of things occurs on Sutherland's Creek near Maude, though in the latter place gastropods, especially cowries, are plentiful; while in the true polyzoal rock, they are extremely rare. Above the limestone comes the clay bed. This for the first few feet is full of polyzoa, resembling those of the lower rock. The beds then pass up in the usual manner into sandy calcareous clays with nodules, and are capped by basalt.

Though the line of demarcation between the polyzoal rock and the grey clay is sharp, still, as has been just mentioned,

the foraminifera persisted during the time required for the deposition of the first few feet of the clay. The muddiness of the water, however, was apparently inimical to the growth of polyzoa in the profusion in which they had previously existed, and they soon ceased to be the typical forms of life in the locality, and the gastropods made their appearance in greater numbers. The effect of the variation in the sediment on the fauna has been alluded to when dealing with the section near the viaduct.

The section is as follows:—

Basalt	60 ft.
Incoherent sandy material, with concretions	20 ,,
Yellow clay, with concretions ...	50 ,,
Grey clay	20 ,,
Polyzoal limestone	30 ,,
Total ...	180 ft.

The hill side is covered by a fairly deep soil, but in a few places, especially where rabbits have burrowed, the underlying rock is exposed. Fossils are scarce, but by dint of a few hours' careful searching, we succeeded in securing examples of thirty-five species, which will be found recorded in the list given.

Below Madden's, the river valley widens out to about three-quarters of a mile. The bed of the stream is formed by the polyzoal limestone for a distance of about half a mile below the section just described, and the rock is carved into miniature caves and hollows by the stream. The top of the limestone approaches the level of the river as we go down stream, owing to the dip of the beds, and at last it disappears under the bed of the stream, its place being taken by the overlying grey clay. Just above Griffin's (see plan 5), where the clay first makes its appearance in the river bed, fossils are plentiful. The banks of the stream are steep and slippery, so that it is a matter of some difficulty to work at the beds. The top of the clay bed is only about a couple of feet above the summer level of the river, and its eroded surface is covered by a gravel wash some ten or twelve feet in thickness.

The fossils found here were remarkable for their size, being far larger than examples of the same species occurring

elsewhere in the valley. We record 113 species from this locality.

For about half a mile below this the river bank exposes an almost continuous section of the clay bed, but this at last disappears, and is overlain by the gravel wash which covers the greater part of the valley.

To the northward on the hill side bounding the valley at (3) and (4), small exposures of the yellowish clay were seen, but only a couple of fossils were obtained. The hill side is thickly masked by soil, principally derived as a pluvial wash from the basalt above. In the places mentioned, however, small gullies have exposed the tertiary rock, though the exposures were so small that we could do no more than satisfy ourselves that the beds were continuous in that direction. Near Coghill's (see plan 2), the stream which has hitherto held a general south-easterly course, bends away to the southward. At this point, a very steep cliff is formed, exposing a section, which attracted the attention of the officers of the Geological Survey. At the base of the cliff occur billowy hillocks formed by the weathering of a small landslip.

The geological survey sheet gives the following section:—

Black loam, with estuary shells and nodules of limestone	8 ft.
Lava	30 „
Loose sand	6 „
Sandy clays, with miocene tertiary fossils	56 „
Total ...	100 ft.

This section, however, seems to need several modifications. The upper surface of the basalt is wackenitic in character, and passes up into the surface soil, and we could not find any trace of the estuary deposit referred to. After a prolonged search, about a dozen specimens of shells were discovered lying close to one another, on the face of the slope towards the cliff. These were all recent species, and are not peculiarly estuary shells. Their colours were perfectly preserved, and they did not appear to have been long in the position in which they were found. The shells were of species of large size, and no examples of small shells were found. The height of the place above the sea

is about 200 ft., and there is no evidence elsewhere, of such a great elevation of the coast within recent times. It seems probable that the shells were carried there by human agency, as similar collections of shells forming the "kitchen middens" of the blacks, are not unknown in other places. A careful examination of the soil did not show any quartzose sand, and the ant-heaps near the spot are covered with small pieces of scoriaceous basalt. Had there been any quartz sand in the deposits, traces of it would certainly have been found on the ant-heaps. Limestone nodules occur, but they are not unknown in decomposed basalt nearer Melbourne, and similar masses may be found near the railway cutting in Royal Park, the lime being probably derived from the decomposition of a lime felspar. A few angular fragments of quartz and quartzite were found on the surface, but are exceedingly scarce. There is certainly no evidence of a marine deposit overlying the basalt anywhere near this locality.

With regard to the 6 ft. of loose sand mentioned on the quarter-sheet, as underlying the basalt, this seems very local in its development. In most places, the clay beds which, as before mentioned, become more sandy in their upper portion, are directly overlain by the basalt, but in a few spots, loose sand does occur. There is no difference in colour between the loose sandy beds, and those containing a small admixture of clay, both being fawn-coloured. The bed of sand is marked Older Pliocene on the map, and is represented as having a continuous outcrop for miles up the valley. The evidence for its separation from the underlying beds is exceedingly slight.

We record 106 species from this locality.

From Coghill's to the Orphanage Hill, the ridge on the left bank maintains a fairly uniform height of about 200 ft. above the river, and falls away gradually on the eastward towards Corio Bay. The country on the right bank had evidently suffered extensive denudation before the basalt outflow took place. The survey quarter-sheet shows the basalt coming right down to the river's edge, from Coghill's to Fyansford (its upper surface being only about 50 ft. or 60 ft. above), while on the other bank, the base of the basalt is about 170 ft. above the river. It is possible, however, that the face of the hill is merely covered by the *débris*, and that the flow is not as deep as shown. For instance, the road-

cutting leading westward from the Fyansford Bridge gives an exposure of the tertiary strata a few feet in extent, at a height of about 40 ft. above the stream. The exposed rock is the yellow clay, with calcareous nodules, so constantly occurring near the top of the series in the neighbourhood. The only fossil we found was an oyster; but a more careful search would probably yield more forms. The tendency of the basaltic *débris* to completely mask a hill side, thus giving an erroneous view of the depth of the flow, is well shown in various places in the valley; and here, when walking along the river bank a few days before noticing the outcrop above, we had no idea that the geological boundary needed a correction. The difference in the level of the basalt on the two sides of the valley is a marked one. Standing on Orphanage Hill, far below the level of the base of the flow, one can see for miles over the basalt plain to the westward; and extensive denudation must consequently have taken place both before and after the outflow of igneous rock.

The geological quarter-sheet gives 10 ft. of loose sand underlying the basalt. This in the map is coloured yellow, indicative of Older Pliocene, and the outcrop is shown extending far up the valley. There is, however, but little doubt as before mentioned, that the deposit is of the same age throughout, and no sufficient grounds exist for dividing it into two parts. The change from clay to sand is a gradual one, which can be traced as we go up the hill on any of the sections exposed in the valley. The change in the character of the sediment naturally affected the inhabitants of the sea, but the fossils which occur in the sandy strata occur in the argillaceous beds as well, and no new forms appear.

The Orphanage Hill section is a very typical one. The grey clays at the base become yellow as they pass upwards, and calcareous nodules and bands make their appearance in the more arenaceous rock near the summit. The beds have been energetically searched for fossils by some of the Geelong collectors, and consequently good specimens are now somewhat difficult to procure. However, as a result of visits on various occasions, we have procured specimens of 192 species from the locality.

In speaking of the polyzoal rock of Western Victoria, Mr. Dennant * mentions that at Muddy Creek the limestone

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* "Proc. A.A.A.S.," 1890, p. 442.

occurs at a lower level than do the gastropod beds, though the actual contact cannot be seen. In South Australia, also, Professor Tate * states that the polyzoal rock is the older of these two members of the series. The evidence we have adduced shows that in this locality as well, the sequence of the beds, as might have been expected, is similar. The deposit at Orphanage Hill, and consequently its extension up the valley of the river is usually spoken of as Oligocene, though coloured Miocene in the quarter-sheet; while the Waurn Ponds rock, which, like the Batesford limestone, is true polyzoal rock, is called miocene. This is, however, a reversal of the true sequence, for the limestone is undoubtedly the underlying member of the series. In his exhaustive examination of the Muddy Creek beds, Mr. Dennant† states that the whole series must be referred to eocene age, and the list of fossils we give, shows that no very marked difference if any at all exists between the ages of the gastropodous clays in the two localities.

OTHER TERTIARY DEPOSITS.

We paid but little attention to the other tertiary deposits. The basalt capping the hills is a portion of the extensive flow of our western plains. The source of the rock is not apparent at any rate in the immediate neighbourhood.

The river valley is covered in most places by drift, varying from fine sand to coarse gravel, consisting principally of quartz. Near Madden's, some greenstone pebbles were obtained, resembling those of the Barwon drift, both above and below the junction with the Moorabool. In the case of the former stream, they are probably derived from the gabbro outcrop, marked on the survey map as occurring about six miles above the junction; but the origin of the pebbles in the Moorabool is not clear. The drift is marked on the geological map as being of pliocene age.

Our thanks are due to Mr. J. Dennant, F.G.S., F.C.S., &c., for his kind assistance in the identification of many of the fossils.

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* "Trans. Roy. Soc. S. Aust.," 1884.

† "Trans. Roy. Soc. S. Aust.," 1888, and "Proc. A. A. A. S.," *loc. cit.* See also "Trans. Roy. Soc. Vict.," 1891, p. 63.

The following shows the number of specimens recorded from each of the localities dealt with in the paper:—

TABLE I.

Filter Quarries	16
Upper Quarry	14

TABLE II.

Orphanage Hill	192
Coghill's	106
Griffin's	113
Near Madden's	35
Near Viaduct	122

The whole number of species is 295, and of these the mollusca and brachiopoda amount to 264.

In comparing the latter with eocene fossils of Muddy Creek, as recorded by Mr. Dennant, we find 145 common to both deposits, and as 102 of the remainder have been only determined generically, being as yet undescribed, it will be seen that the agreement between the beds is exceedingly close.

TABLE I.

Name of Specimen.	Locality where Obtained.	
	* Filter Quarries.	Upper Quarry.
Foraminifera.		
Orbitoides mantelli	x	x
Amphistegina sp.	...	x
Operculina sp.	...	x
Gypsina sp.	...	x
Corals.		
Placotrochus deltoideus, Duncan	x	...
„ elongatus, Duncan	x	...
Flabellum gambierense, Duncan	x	...
Isis sp.	x	...
Echinodermata.		
Pericosmus gigas, McCoy	x	x
„ sp.	x	...
Clypeaster gippslandicus, McCoy	x	x
Monostychia australis, McCoy	x	...
Brachiopoda.		
Waldheimia garibaldiana, Davidson ...	x	x
Magasella compta, Sow	x	...
„ woodsiana (?), Tate	x	...
Terebratulina davidsoni, Etheridge	...	x
Lamellibranchiata.		
Pecten murrayanus, Tate	x	x
„ polymorphoides, Zittel	x	...
„ subbifrons, Tate	...	x
Spondylus pseudo-radula, McCoy	...	x
Nucula sp.	...	x
Ostræa sp.	x	x
Gasteropoda (a few casts)	...	x
Pisces.		
Lamna sp.	x	...

* NOTE.—These quarries are both in the Polyzoal Rock, and are marked Filter Quarries (7), and Upper Quarry (8), on the plan.

TABLE II.

Name of Specimen.	Locality where Obtained.				
	Orphanage Hill.	Coghill's.	Griffin's.	Near Madden's.	Near Viaduct.
Foraminifera.					
Orbitoides mantelli	...	...	x	x	...
Other genera and species ...	x	...	x	x	x
Corals.					
Placotrochus deltoideus, Duncan ...	x	x	x	...	x
„ elongatus, Duncan ...	x	x	x	...	x
Flabellum gambierense, Duncan ...	x	x	x	...	x
„ victoriæ, Duncan ...	x	x	...	x	x
Notocyathus viola, Duncan ...	...	x	x	...	...
„ australis, Duncan ...	...	x	x	...	...
„ sp.	...	...	...	x	...
Trematotrochus (?) sp.	...	...	x	...	...
Balanophyllia australiensis, Duncan	x	x	...	...	x
Other species	x	x	x	x	...
Echinodermata (indeterminate casts; also spines)	x	x	x	x	x
Crustacea	...	x	...	x	...
Polyzoa (various species)	x	x	x	x	x
Salenaria sp.	...	...	x	...	...
Brachiopoda.					
Waldheimia garibaldiana, Davidson	x	x	x	...	x
„ insolita, Tate ...	...	x	...	...	x ?
„ corioensis, McCoy ...	...	x	...	...	x
Terebratula vitreoides, T. Woods ...	x	x ?	...	...	..
Terebratulina scoulari, Tate ...	...	x ?	...	...	...
„ sp.	...	x	x	...	x
„ davidsoni, Etheridge	...	...	...	x	...
Lamellibranchiata.					
Pecten murrayanus, Tate ...	x	...	...	...	x
„ sturtianus, Tate	x	...	...	...	x
„ semilaevis, McCoy ...	...	...	...	...	x

Name of Specimen.	Locality where Obtained.				
	Orphanage Hill.	Coghill's.	Griffin's.	Near Madden's.	Near Viaduct.
Lamellibranchiata—continued.					
Pecten yahlensis, T. Woods ...	...	...	...	...	x
„ zitteli, Hutton	...	...	...	...	x
„ sp.	x	...	...	2 sp. (frag.)	x
„ foulcheri, T. Woods ...	x	...	...	...	...
„ gambierensis, T. Woods ...	...	...	x	...	...
Spondylus pseudoradula, McCoy ...	x	x	x	...	x
Dimya dissimilis, Tate	x	x	...	x	x
Pectunculus m'coyii, Johnston ...	x	x	x	x	...
„ cainozoicus, T. Woods	x	...	x	...	...
Limopsis belcheri, Adams and Reeve	x	x	x	x	x
„ aurita, Brocchi ...	x	x	...	x	x
Lima bassii, T. Woods	x	...	...	...	...
„ linguliformis (?), Tate ...	x	...	...	...	...
Leda vagans, Tate	x	x	x	x	x
„ obolella, Tate	x	...	...	...	...
„ apiculata, Tate	...	x ?	...	...	x
„ sp.	x	...	...	...	x
„ sp.	...	...	...	x	...
Trigonia tubulifera, Tate ...	x	x	...	...	...
Barbatia celleporacea, Tate ...	x	...	...	...	x
Macrodon cainozoicus, Tate ...	x	...	...	x	x
Cardita gracilicostata, T. Woods ...	x	x	...	x	x
„ compacta, Tate	x	x	x	...	x
„ scabrosa (?), Tate ...	x	...	...	...	x
„ sp. nov. (?)	x	...	...	frag.	...
„ polynema, Tate	x	...	...	...	...
„ delicatula, Tate	x	x	x	...	...
„ sp.	...	...	...	...	x
Nucula tumida, T. Woods ...	x	x	x	...	...
„ morundiana, Tate ...	x	...	...	...	...
„ atkinsoni, Johnston ...	...	...	...	...	x
Chama lamellifera, T. Woods ...	x	...	x	...	x
Myodora tenuilirata, Tate ...	x	...	x	...	x
Semele vesiculosa, Tate	x	...	...	...	...
Cytherea eburnea, Tate	x	x	x	...	x
„ sp.	x	...	...	...	...
Chione sp.	x	...	x	...	x
„ sp. (nov.)	...	...	x	...	...

Name of Specimen.	Locality where Obtained.				
	Orphanage Hill.	Coghill's.	Griffin's.	Near Madden's.	Near Viaduct.
Lamellibranchiata—continued.					
Chione sp.	x	...	...	...	...
Crassatella dennanti, Tate ...	x	...	x	...	x
„ astarteformis, Tate ...	x	x	x	...	x
Ostræa hyotis	x	...	...	...	x
„ sp.	x	x	...	x	x
Cardium antisemigranulatum, McCoy	x	...	...	...	...
„ sp.	x	...	...	...	...
Cucullaea corioensis, McCoy ...	x	...	x	...	...
Corbula ephamilla, Tate... ...	x	x	x	...	x
„ pixidata, Tate	x	x	x	...	x
Hinnites corioensis	...	x	...	...	x
Modiola sp.	...	...	x	...	...
Gasteropoda.					
Typhis laciniatus, Tate	...	...	x	...	...
„ sp.	x	x	...	...	x
„ m'coyii, T. Woods ...	x	...	...	...	...
„ evaricosus, Tate	...	...	x	...	...
Murex lophoessus, Tate ...	x	...	...	...	...
„ velificus, Tate	x	...	...	...	x
„ amblyceras, Tate ...	x	x	...	...	...
„ trochispira, Tate ...	x	...	...	...	...
„ camplytropis, Tate ...	x	...	...	...	...
„ eyrei, T. Woods... ..	x	...	...	...	...
„ asperulus, Tate	x	x	...	...	x
„ sp.	...	...	...	...	x
Trophon polyphyllus, T. Woods ...	x	x	...	...	...
Ranella prattii, T. Woods ...	x	x	x	...	x
Rapana aculeata, Tate	x	...	x ?	...	...
Triton cyphus, Tate	x	...	x	...	x
„ tumulosus, Tate	x	...	x	...	x
„ woodsii, Tate	x	x	x	...	x
„ gemmulatus, Tate ...	...	...	...	...	x
„ tortirostris, Tate	...	...	x	...	x
„ textilis, Tate	x	...	...	...	...
„ sp.	x	...	...	...	...
Fusus dictyotis, Tate	x	...	...	...	...
„ craspedotus, Tate ...	x	x	...	...	...

Name of Specimen.	Locality where Obtained.				
	Orphanage Hill.	Coghill's.	Griffin's.	Near Madden's.	Near Viaduct.
Gasteropoda—continued.					
Fusus acanthostephes, Tate ...	x	x	...	...	x
„ foliaceus, Tate	x	...	x	...	...
„ aciformis, Tate	...	...	x	...	...
„ senticosus, Tate	x	...	...	...	...
„ hexagonalis, Tate ...	x	...	...	...	...
Fasciolaria cryptoploca, Tate ...	x	...	...	...	...
„ decipiens (?), Tate ...	x	...	...	...	...
„ rugata, Tate	x	x	x	...	...
„ cristata, Tate ...	...	...	x	...	...
Peristernia subundulosa, Tate ...	x	...	...	...	x
„ lintea, Tate	...	...	x	...	...
Sipho sp.	..	x	2 sp.	...	...
„ asperulus, Tate	x	...	...	...	x
Siphonalia, sp.	x	...	...	...	...
Dennantia ino, T. Woods ...	x	...	...	...	...
„ cingulata (var.), Tate ...	x	x	x	...	...
Leucozonia sp....	...	x	...	...	...
Nassa tatei, T. Woods	x	x	x	x	x
Voluta hannafordi, McCoy ...	x	...	x	...	...
„ antiscalaris, McCoy ...	x	x	...	...	x
„ strophodon, McCoy ...	x	x	...	...	x
„ ancilloides, Tate	x	...	...	...	...
„ m'donaldi, Tate ...	x	...	...	...	...
Voluta costellifera, Tate ...	x ?	...	...	...	x
„ (volutoconus) conoidea, Tate	x	...	...	...	...
„ pseudolirata, Tate ...	x	...	...	...	...
„ cathedralis, Tate ...	x ?	...	...	.	...
„ sp. nov.	...	...	...	...	x
„ polita, Tate	...	...	...	...	x
„ sp.	...	...	...	...	x
Lyria harpularia (?), Tate ...	x	...	...	...	...
Mitra atractoides, Tate	x	...	...	...	...
„ alokiza, T. Woods ...	x	...	...	...	...
„ ligata, Tate	x	x	x	...	x
Marginella woodsii, Tate ...	x	x	...	..	x
„ propinqua, Tate ...	x	x	x	...	x
„ wentworthi, T. Woods	x	...	juv.	x	x
„ inermis, Tate ...	x	...	...	...	...

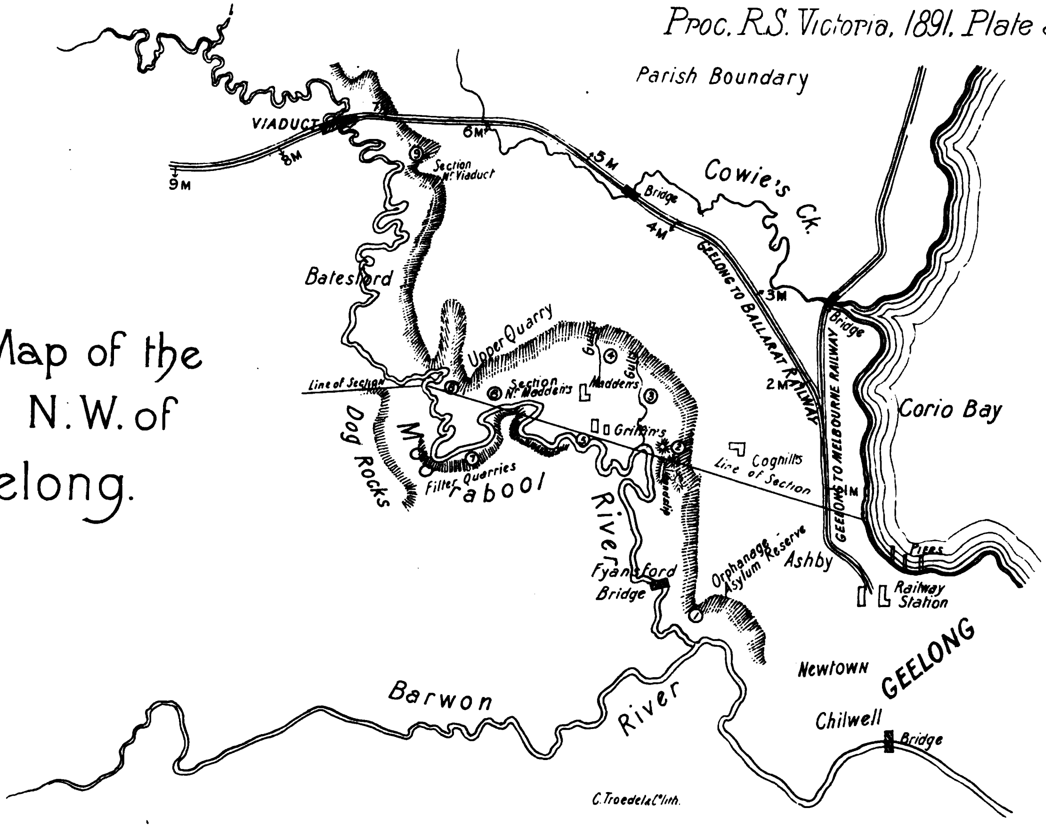
Name of Specimen.	Locality where Obtained.				
	Orphanage Hill.	Coghill's.	Griffin's.	Near Madden's.	Near Viaduct.
Gasteropoda—continued.					
Marginella (juv.)	x	...	...	...	...
„ micula (var.), Tate ...	...	...	...	...	x
„ sp.	...	...	...	...	x
Oliva, sp.	x	...	...	...	...
Ancillaria pseudaustralis, Tate ...	x	...	x	...	...
„ sp.	x	...	...	...	...
„ sublaevis (?), T. Woods	...	x	...	..	...
Harpa sp.	x	...	...	...	...
Cancellaria varicifera, T. Woods ...	x	x	..	...	x
„ sp.	...	...	...	x	...
„ laticostata, T. Woods ...	x	...	...	..	x
Terebra platyspira, Tate ...	x	...	...	...	...
Pleurotoma haastii, Hutton ...	x	x	x	...	x
„ murndaliana, T. Woods	x	x	...	...	x
„ clarae, T. Woods ...	x	x	x	x ?	x
„ sp.	x	x	x	...	...
„	2 sp.	...	...	...	...
„	...	...	6 sp.	...	...
„	...	4 sp.	...	...	...
„	...	...	...	...	4 sp.
Drillia trevori, T. Woods ...	x	x	x		x
„ integra, T. Woods ...	x	x	x	..	x
„	6 sp.	...	...	...	...
„	...	6 sp.	...	...	...
„	...	...	2 sp.	...	...
„	...	...	...	...	1 sp.
Mangelia	7 sp.	...	..	..	...
„	...	3 sp.	...	...	...
„	...	...	4 sp.	...	...
„	...	...	...	...	5 sp.
„ bidens, T. Woods ...	x	x	x	...	x
Bela sp.	x	...	...	...	...
Conus hamiltonensis, Tate ...	x	...	...	...	...
„ (aff. pullulescens), T. Woods	...	x	...	...	...
„ sp.	x	..	...	...	...
„ ligatus, Tate	x	...	x	...	...
Cypraea eximia, McCoy	x	...	juv.	x ?	x
„ gigas, McCoy	x	frag.	x	...	frag.

Name of Specimen.	Locality where Obtained.				
	Orphanage Hill.	Coghill's.	Griffin's.	Near Madden's.	Near
Gasteropoda—continued.					
Cypraea leptorhyncha, McCoy ...	x	x	...	...	x
„ contusa, McCoy ...	x	...	...	...	x ?
„ pyrulata, Tate	x	...	...	...	...
„ subsidua, Tate	x	...	...	...	...
„ subpyrulata, Tate ...	x	...	...	...	...
„ sp.	...	x	..	...	x
„ sp.	...	...	x	...	...
Trivia avellanoides, McCoy ...	x	x	x	...	x
Cassis exigua, T. Woods ...	x	...	...	...	frag.
Semicassis transenna, Tate ...	x	...	...	...	...
Cassidaria sp.	x	...	...	...	...
Natica hamiltonensis, T. Woods ...	x	x	x	...	x
„ gibbosa, Hutton	x	x	x	...	...
„ polita, T. Woods ...	x	x	x	...	x
„ auriculata, Tate, m.s. ...	x	...	...	...	...
„ (?) sp. (nov.)	...	...	...	...	x
Crepidula sp.	x	...	...	...	...
Calliostoma sp.	x	...	2 sp.	x	...
Astele sp.	...	...	...	...	x
Xenophora agglutinans, Lam. ...	x	...	...	...	x
Solarium acutum, T. Woods ...	x	...	..	...	x
Scalaria sp.	x	...	...	...	...
Turritella murrayana	x	x	x	...	...
„	4 sp.	...	...	1 sp.	...
„	...	3 sp.	...	...	...
„	...	...	4 sp.	...	...
„	...	...	...	...	3 sp.
Siliquaria squamulifera, Tate, m.s.	x	x	x	...	x
„ sp. nov.	x	...	x	...	...
Eulima danae, T. Woods ...	x	...	...	...	...
„ sp	...	x	...	...	...
Niso psila, T. Woods	x	x	x	...	x
Cerithium apheles, T. Woods ...	x	x	x	...	x
„ sp.	x	...	x	...	...
„ sp.	...	x	...	...	...
Triforis wilkinsoni, T. Woods ...	x	...	...	...	...
„	3 sp.	...	...	...	...
„	...	...	2 sp.	...	...

Name of Specimen.	Locality where Obtained.				
	Orphanage Hill.	Coghill's.	Griffin's.	Near Madden's.	Near Viaduct.
Gasteropoda—continued.					
Triforis	...	...	..	...	1 sp.
Mathilda sp.	x	...	...	...	...
Liotia sp.	x	...	...	...	...
„ sp.	...	...	x	...	...
„ sp.	x	...	...	...	...
Cyclostrema (?) sp.	...	...	...	...	x
Fissurellidæa malleata, Tate ...	x	x	x	...	...
Hemitoma occlusa, Tate, m.s. ...	...	...	x	...	x
Emarginula candida, Tate, m.s. ...	x	...	...	...	...
„ sp.	x	x	...	...	...
„ sp.	x	...	...	...	...
„ cymbium (?), Tate, m.s.	...	...	...	...	x
„ sp.	...	...	x	...	...
Entalis mantelli, Zittel	x	x	x	x	x
„ annulatum, Tate ...	x	x	x	x	x
Dentalium aratum, Tate ...	x	x	x	x	x
Cylichna exigua, T. Woods ...	x	...	x	...	...
„ sp.	x	...	...	...	...
„ sp.	...	...	...	...	x
„ sp.	...	...	x	...	...
Dolichotoma sp.	x	x	x	...	x
Magilus sp.	...	...	...	...	x
Vermetus (?) sp.	x	...	x	...	x
Scaphander fragilis, Tate, m.s. ...	x	...	...	...	...
Bulla scrobiculata	x	...	...	...	...
„ sp.	...	x	...	...	x
Ringicula australis (?)	x	...	...	...	...
„ sp.	...	...	x	...	...
Pusianella hemiothone	...	x	...	..	...
„ sp.	x	...	...	...	...
„ sp.	...	...	...	...	x
Columbella cainozoica, T. Woods ...	...	x	...	...	x
Clathurella sp.	...	x	...	...	...
Daphnella gracillima, T. Woods ...	...	...	x	...	...
„ sp. (?)	...	x	...	...	...
Delphinula sp.	...	x	...	...	...
Eburnopsis sp.	...	...	x	...	...
Rissoa (?) chrysalida, Tate, m.s. ...	...	...	x	...	...

Name of Specimen.	Locality where Obtained.				
	Orphanage Hill.	Coghill's.	Griffin s.	Near Madden's.	Near Viaduct.
Gasteropoda—continued.					
Trochocochlea (?) sp.	...	...	x	...	...
Cephalopoda.					
Aturia australis, McCoy ...	x	...	...	...	...
Nautilus sp.	x	...	...	...	...
Pisces.					
Shark's teeth (2 species) ...	x	...	...	x	...
Ear bones	...	x	x	3 sp.	x

Sketch Map of the District N.W. of Geelong.

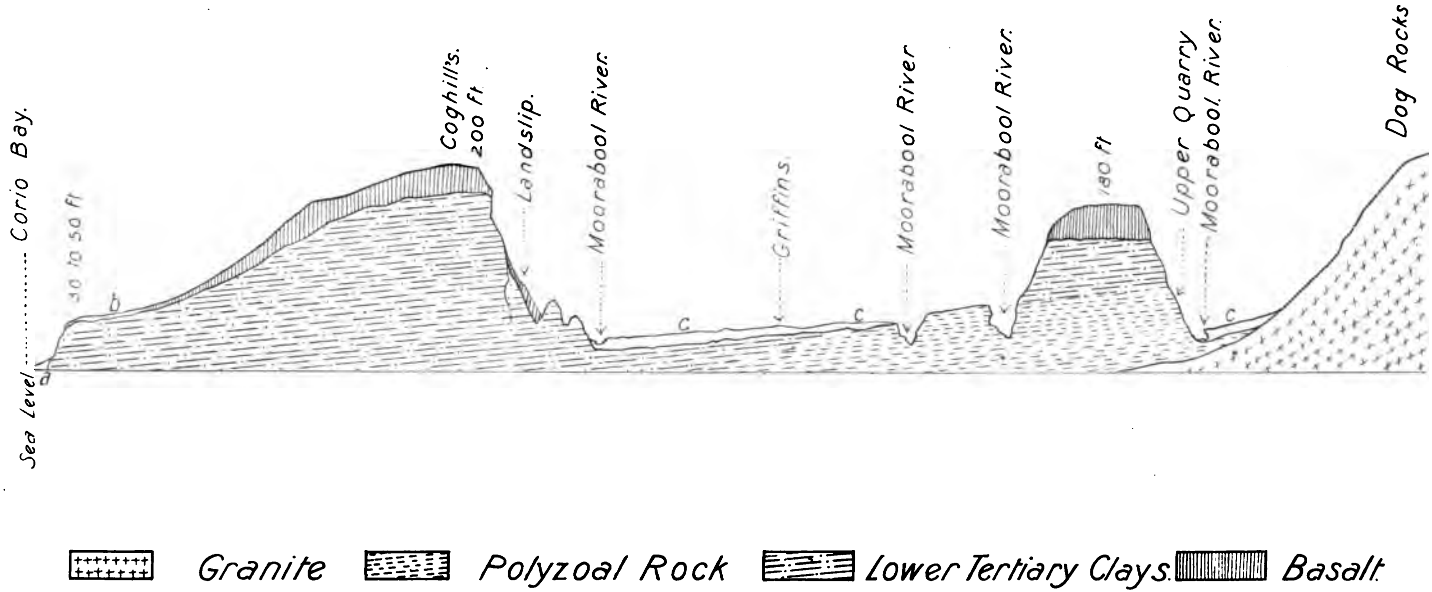


C. Troedel & Co. lith.

Section from Corio Bay to the Dog Rocks.

DISTANCE about 6 miles.

Horizontal scale 1¼ inch to 1 mile.



a. Raised Sea Beach. b. Newer Pliocene. c. Fluvial Wash.

al, T. S. 1893

Royal Society of Victoria.

2

NOTES ON THE EOCENE STRATA OF THE BELLARINE PENINSULA WITH BRIEF REFERENCES TO OTHER DEPOSITS.

BY

T. S. HALL, M.A., AND G. B. PRITCHARD.

Ford & Son, Printers, 372 & 374 Drummond Street, Carlton.

ART. I.—*Notes on the Eocene Strata of the Bellarine Peninsula with brief references to other deposits.*

(With Plate I.)

By T. S. HALL, M.A., and G. B. PRITCHARD.

[Read 9th March, 1893].

Our chief inducement for visiting the Bellarine Peninsula was the object of settling on palæontological evidence whether the small outcrop marked on the maps (¼ sheet 23 S.W.) belongs to eocene or to miocene age, the two sets of beds having been elsewhere confused. Certain peculiarities of the deposits however induced us to extend our observations to other portions of the district where similar beds are exposed.

The Peninsula consists of a central mass of the Jurassic fresh-water series, an outlying portion of the Barrabool and Otway beds. Overlying these beds in their northern area occurs the Older Basalt, affording by its decomposition the rich soil for which that part of the district is so well known. Surrounding this central mass is a ring of marine eocene beds. Exposures of the latter occur on the northern and southern boundaries where-ever the natural conditions afford an opportunity of seeing them. On the eastern and western sides no exposures are to be seen as the thick mantle of upper tertiary beds covers the slopes and flats and hides the underlying series from view. There is little doubt however that the ring is complete, as to the westward the Geelong eocenes, as represented by the Corio Bay, Moorabool Valley and Belmont beds are well developed, while to the eastward the Mornington beds occur just across the bay, and as Mr. Daintree reports* similiar beds were passed through in the Queenscliff bore.

The jurassic rocks, although occuping such a large extent of the peninsula, show only one small outcrop just to the westward of Portarlington.† A syncline occurs between the Bellarine beds

* Parl. Rep., 1861-62, A 43. † ¼ Sheet 23 N.E. Note.

and those of the Barrabools, the latter dipping easterly and showing in a series of outcrops the beds proved in the Bellarine bores.*

THE OLDER VOLCANIC.

Along the cliffs at Portarlington the older volcanic rock occurs on both sides of the pier and exhibits various degrees of decomposition. In one place it is quarried for road metal, while to the east it is a soft unctuous clay which can be traced along the cliffs gradually showing more and more its true character till it disappears below sea level. In this locality it is overlain by coarse ferruginous grits which are probably of upper tertiary age. Near the Clifton Springs it forms the greater part of the cliffs. Here, at about thirty feet above sea level, it is covered by a conglomerate consisting of sub-angular and well rounded pebbles up to four or five inches in diameter, and comprising quartz in various forms, hard blue metamorphic sandstones, nodular schists, and other altered argillaceous rocks with beds of sand and clay. Towards the top it gradually becomes finer and more sandy. At the Drysdale Pier hard ferruginous grits come down to the water's edge, the volcanic rock having been here, as elsewhere, deeply denuded. At the next point, about a quarter of a mile west of the pier, the beach floor and cliffs consist of a volcanic ash or breccia, full of angular fragments of scoriaceous basalt up to an inch in diameter. The deposit is well and evenly bedded and has a dip some degrees west of north at about 20°. Decomposition has considerably affected the strata and the colours are very variable, being blue, gray, dark-green, fawn and chocolate. From here, for about 2½ miles westward, these ash beds are almost continuously exposed to view on the beach floor with intermissions to be mentioned presently. In some places the cliffs are seen to be almost entirely composed of ash overlain by a variable thickness of upper tertiary clays and grits. The ash beds gradually sink to sea level and disappear near the boundary between the parishes of Bellarine and Moolap, where they are overlain by eocene beds. These continue for nearly half a mile, when ash beds again appear from beneath them with a north-easterly dip. We roughly estimated a thickness of 300 feet of

* ¼ Sheet 24 S.E. Note 7.

ash to be exposed here. At the place marked Ad 12 on the ¼ Sheet, which is the most prominent point between Clifton and Point Henry, a dyke of fine, dense basalt occurs in the ash. The included fragments in the ash beds here are of larger size, some being upwards of two feet in diameter, and consist principally of masses of basalt, though a few embedded blocks of brownish sandstone, and of an altered yellow argillaceous rock were visible. The latter are probably derived from the underlying mesozoic rocks, though considerably altered in appearance and hardness, they at any rate do not resemble any of our Silurian rocks. From the size of the ejected masses, and from the presence of the dyke, it is probable that we are here close to a vent of the Older Volcanic rock, the greater part of the core having been removed by denudation. Overlying the ash at this point and on its eroded surface occurs a sheet of polyzoal rock. That it does not consist of ejected fragments is clear from its well bedded structure and from its constant dip. It occurs in large tabular masses and is nowhere seen overlain by the volcanic rock. It has for the most part been removed on the higher parts of the beach, where loose blocks of it occur; but at low-tide it may be seen to form a fairly continuous sheet passing out under water to the north. In most places it is altered to a crystalline reddish rock, the weathered surfaces of which are crowded with fossils standing up in relief, and the usual cream colour, which characterises the rock in other localities, prevails. The fossils are principally polyzoa though brachiopods, lamellibranchs and gastropods occur. Similar rock occurs at Sutherland's Creek, near Maude, and again in the Moorabool Valley,* and is at the latter place not associated with igneous rock. At the parish boundary, (Locality 1) where we first noted the eocene beds, the dip of the ash beds and of the former is approximately to the north-west and the volcanic series can be seen passing beneath the fossiliferous strata. So that in these two places we have evidence, that here, the older volcanic rocks are antecedent to the eocene series, and not overlying them as indicated in Daintree's report on the district† and by the colouring and lettering on ¼ sheets 23 S.E. and 23 S.W.

* Proc. Roy. Soc. Vic., vol. iv, N.S., p. 11. † Parl. Report, 1861-62, A 43.

In the ¼ sheets (23 S.W. and 23 S.E.) dealing with this portion of the district, some confusion exists as to the volcanic rocks. The large outcrop forming the Bellarine Hills is marked as older volcanic, of which it is regarded as forming a typical locality. On the west side of the road from Portarlington to Drysdale, the lettering in the two places indicates newer pliocene overlying older volcanic in one case close to the cliff, while the cliff section shows an outcrop coloured to represent lower volcanic ('pliocene'), but not lettered. On ¼ sheet 23 S.W. the same outcrop is shown running along past Clifton Springs, with one intermission, to a short distance past the dyke we have alluded to. This intermission should not occur, as the ash beds crop out continuously along the beach at this place. Both these separated portions of the same outcrop are marked V. 1, 2, 3, that is, as the legend shows, lower volcanic ('pliocene') basalt dolerite, anamesite and lava, while V. 4 (ash, conglomerate, &c.) is omitted, although a section of over two miles in length is exposed. This is not all, for a note near the parish boundary and close to the volcanic outcrop states that "the basalt outcrop of the Bellarine Hills probably underlies the pliocene tertiary sands and ironstones as far south as the heads of the creeks falling into Corio Bay." So that this outcrop is coloured 'pliocene' and alluded to as 'miocene;' while the true state of the case is that it is unconformably overlain by the clays which were then called miocene or oligocene but which are now regarded as eocene.

THE CURLEWIS EOCENES.

This will be a convenient name for this section, as the hamlet of Curlewis is situated on the Portarlington Road, about a mile to the southward.

It is probable, as will presently appear, that the sequence of eocene beds here is similar to what occurs in the Moorabool Valley,* that is, that the polyzoal rock, where it occurs, is the underlying member of the series, though we were unable to absolutely prove the succession.

At the first place where we noted the eocene beds (parish boundary), they consisted of blue clays resting on ash beds, the

* Proc. Roy. Soc. Vic., vol. iv., N.S., pp. 9 et seq.

dip of both deposits being to the seaward. This dip is the most marked peculiarity of the beds in this locality. There occurs a band of about six feet in thickness of marked character which can be traced, with but few intermissions, for two miles along the coast. Its upper portion consists of about three feet of dark-brown earthy limestone, very sandy, and containing casts of fossils; below this, is about 18 inches of gray clay and then about the same thickness of a rock similar to the upper band, but more easily weathered and of a lighter hue. Both above and below this band, occur stiff blue clays similar to those of Mornington, Spring Creek and the Gellibrand. The angle of dip averages about 25°. In some places it is as low as 10° and near the western end of the section for about 30 yards it dips at 45°. Dipping as the beds do, this hard band stands out from the softer clays like a wall, usually from two to three feet above the almost level floor of the beach. The beds as shown by this band are contorted and faulted. At the parish boundary, we can on ascending the low cliff, see the band coming in to the shore from the north-east and winding with a serpentine curvature. It sweeps round the point in one curve, the dip swinging through an arc of 90°, from a few degrees east of north to a few degrees north of west. Numerous small faults occur, trending north-west, the throw being usually a few inches and rarely exceeding a foot, and the hade nearly vertical. In one place we counted six faults in about 50 yards Along this outcrop the easterly beds are shifted to the north, or in other words, the downthrow is to the south-west. We thus have displayed a beautiful series of step faults. In one place on the curve however, the band between two faults has gone out into deep water, and although the tide was low we could not find any trace of the band *in situ*. Actual measurement showed a lateral displacement of over 30 feet while the loose blocks in the water, which stopped further measurement, showed the direction in which displacement had taken place.

The clay above and below the band is full of nodules of iron pyrites. In places slight hollows on the beach are full of loose pieces washed out, and covered with a crust of limonite. Occasionally, below the band the pyrites has oxidized *in situ*, and has stained the clay yellow. This decomposition is however more frequent in the clay overlying the band and the general tint is consequently of a lighter hue.

Blocks of the earthy limestone band occur on the beach at this point, above high-water mark, and lithologically closely resemble eocene rocks forming the cliffs on the western shores of Corio Bay. From these blocks we procured the following fossils:

Dimya dissimilis, Tate.
Pecten Yahlensis, T. Woods.
Spondylus pseudoradula, McCoy.
Waldheimia divaricata, Tate.
Polyzoa.
Echini spines.

The clays of this place (Locality 1) however, yielded a far greater number of forms, as shown by the following list, which is the result of but a few hours work.

List of Fossils from Locality 1.

Class, Zoantharia.
Placotrochus deltoideus, Duncan.
Flabellum Victoriæ, Duncan.
Conosmilia anomala, Duncan.

Class, Echinodermata.
Cidaroid spines.

Class, Polyzoa.
Numerous genera and species.

Class, Palliobranchiata.
Terebratulina Scoulari, Tate.

Class, Lamellibranchiata.
Pecten dichotomalis, Tate.
,, Foulcheri, T. Woods.
,, (Amussium) Zitteli, Hutton.
Lima Bassii, T. Woods.
Limea transenna, Tate.
Modiolaria singularis, Tate.
Crenella n. sp. aff. globularis.
Nucula tumida, T. Woods.
,, Atkinsoni, Johnston.
Leda Huttoni, T. Woods.
,, apiculata, Tate.
,, obolella, Tate.

Pectunculus laticostatus, Quoy and Gaimard.
Macrodon Cainozoicus, Tate.
Cucullæa Corioensis, McCoy.
Cardita sp.
Chama lamellifera, T. Woods.
Chione? n. sp.
Myadora tenuilirata, Tate.

Class, Gastropoda.

Ranella Prattii, T. Woods.
Triton tortirostris, Tate.
Fusus craspedotus, Tate.
Peristernia lintea, Tate.
" sp.
Zemira præcursoria, Tate.
Voluta antiscalaris, McCoy.
" McCoyii, T. Woods.
" n. sp. = Spring Creek.
" (Volutoconus) n. sp. aff. conoidea.
Lyria harpularia, Tate.
Mitra atractoides, Tate.
Marginella propinqua, Tate.
" sub-Wentworthi, Tate.
" micula, Tate.
" sp.
Ancillaria hebera, Hutton.
" pseudaustralis, Tate.
Columbella clathrata, Tate, m.s.
" sp.
Cancellaria Etheridgei, Johnston.
" n. sp.
Pleurotoma sp.
Drillia sp.
Mangilia sp.
? " sp.
Raphitoma n. sp.
Pusianella aff. hemiothone.
" n. sp.
Conus heterospira, Tate.
Cypræa brachypyga, Tate.

Semicassis transenna, Tate.
Cassidaria gradata, Tate.
Natica Hamiltonensis, T. Woods.
Crepidula sp.
? Scalaria sp.
Turritella Murrayana, Tate.
" sp.
" sp.
Vermetus sp.
Niso psila, T. Woods.
Cerithiopsis n. sp.
Delphinula aster, T. Woods.
Scaphander fragilis, Tate, m.s.
Ringicula sp.
Cylichna exigua, T. Woods.

Class, Scaphopoda.

Entalis Mantelli, Zittel.
" subfissura, Tate.

Class, Pisces.

Otoliths.

SUMMARY FOR LOCALITY 1.

Class.	No. of Species.
Zoantharia - - - -	3
Palliobranchiata - - -	1
Lamellibranchiata - - -	19
Gastropoda - - - -	46
Scaphopoda - - - -	2
Pisces - - - - -	1
Total - - - -	72

At the point where the polyzoal rock occurs, and on the west side of the gully two intersecting faults, trending N.E. and N., are distinctly traceable on the beach, as they have lowered the eocene blue clay into the ash beds. Each of these faults is visible for several yards, as the clay, being softer than the volcanic rock at this point, has been removed by the waves to about a foot below

the level of the latter. A third fault, completing the triangle and having the N.W. trend of all the other faults observed, probably occurs to the westward, but was not visible. The position of the clay beds here, lends force to the view already stated that the polyzoal rock underlies the clay, as close at hand the limestone is seen *in situ* in contact with the volcanic rock; while the downthrow of a fault has been necessary to bring the clay to its level.

About two hundred yards west of this point (Locality 2 on plan) we again find the band, described above, making its appearance, and being traceable for nearly half-a-mile along the shore before disappearing beneath the upper tertiary beds to the west. At the former place where we described it, it has a northerly dip and the lowest beds are on the landward side. Here however, the dip is reversed and the lower beds are to the seaward, a syncline running N.E. and S.W. The strata can be fairly termed contorted. A system of faults with a north-westerly trend is again developed, with the same average throw. Our time did not allow us to work out the directions of the downthrow, the matter being complicated by the contortion of the strata.

To show the way in which contortion has taken place a few examples may be given. At one place the band dips W.—S.—E. at 10°, the radius of curvature of the outcrop being about 20 feet and the upper beds being inside the curve. Then the western end of the band curves round, dipping S.E.—S.—S.W. at 25°, the radius of curvature being 30 feet and the upper beds being on the outside of the curve. The band is curved three or four times in a similar manner to the westward of this point within a distance of a few hundred yards, and it is at this end of the section that we noted the dip as 45° for 30 feet of strike.

Although the beds are so much disturbed the number of crushed shells does not seem greater than usual. Even close to the faults, large shells were perfect. Some specimens which were in contact with pyrites nodules were crushed, but for the most part the fossils were beautifully preserved. From the earthy limestone band of this locality (2) we gathered the following forms :—

Waldheimia divaricata, Tate.
„ insolita, Tate.

Dimya dissimilis, Tate.
Pecten Foulcheri, T. Woods.
Chione Cainozoica (?), T. Woods.
Leda sp. (cast).
Pectunculus laticostatus, Quoy and Gaimard.
Cypraea leptorhyncha, McCoy.

As before, however, the clay beds were the most prolific in fossils, and we give a list of the species gathered, together with references showing their occurrence in some other localities. In this table, the forms gathered at Locality 1 but which were not obtained at Locality 2 are marked with the sign †.

Fossils from Curlewis.	Belmont.	Schnapper Point.	Spring Creek.	Muddy Creek.
Class, Rhizopoda.				
Order, Foraminifera.				
Biloculina sp.	-	X	-	X
? Miliolina sp.	-	X	X	X
? Orbitolites sp.	-	-	-	X
Other genera and species	-	X	X	X
Class, Actinozoa.				
Order, Zoantharia.				
Flabellum Victoriæ, Duncan	X	X	X	X
Placotrochus deltoideus, Duncan	X	X	X	X
Conosmilia anomala, Duncan	X	X	X	X
Class, Echinodermata.				
Lovenia Forbesi, Duncan	-	-	X	-
† Cidaroid spines	X	X	-	X
Class, Polyzoa.				
Numerous genera and species	-	X	X	X
Class, Palliobranchiata.				
Waldheimia divaricata, Tate	-	-	-	-
† Terebratulina Scoulari, Tate	-	X	X	X
Class, Lamellibranchiata.				
Ostræa ? n.sp.	-	-	-	-
Dimya dissimilis, Tate	X	X	X	X
Pecten dichotomalis, Tate	-	X	-	-
„ Yahlensis, T. Woods	-	X	X	X
„ Foulcheri, T. Woods	X	X	X	X
† „ (Amussium) Zitteli, Hutton	X	X	X	X
Lima Bassii, T. Woods	X	X	-	X
† Limea transenna, Tate	-	X	-	X

Fossils from Curlewis.	Belmont.	Schnapper Point.	Spring Creek.	Muddy Creek.
Spondylus pseudoradula, McCoy	-	X	-	X
Septifer fenestratus, Tate	X	X	-	X
† Modiolaria singularis, Tate	-	X	-	X
† Crenella n.sp. aff. globularis	-	-	-	-
Nucula tumida, T. Woods	-	X	X	X
„ Atkinsoni, Johnston	-	X	-	X
„ Morundiana, Tate	X	-	X	X
† Leda obolella, Tate	-	X	-	X
„ Huttoni, T. Woods	X	X	X	X
„ apiculata, Tate	X	X	? X	X
„ praelonga, Tate	-	X	-	X
Limopsis Belcheri, Adams and Reeve	X	X	X	X
Pectunculus laticostatus, Quoy and Gaimard	X	X	X	X
Macrodon Cainozoicus, Tate	X	X	X	X
Cucullæa Corioensis, McCoy	X	X	X	X
Crassatella astartiformis, Tate	X	X	X	X
Cardita polynema, Tate	? X	X	X	-
„ delicatula, Tate	X	X	X	X
Chama lamellifera, T. Woods	X	X	X	X
Chione Cainozoica ? T. Woods	-	X	X	X
† „ ? n.sp.	-	-	-	-
† Myadora tenuilirata, Tate	-	X	X	X
„ n.sp.	-	-	-	-
Corbula ephamilla, Tate	X	X	X	X
„ pixidata, Tate	X	X	X	-
Class, Gastropoda.				
Murex velificus, Tate	X	X	X	X
„ rhysus, Tate	-	X	-	X
„ Dennanti, Tate	-	-	-	X
„ Eyrei, T. Woods	X	X	X	X
„ n.sp.	-	-	-	-
Typhis acanthopterus, Tate	X	X	-	-
Rapana aculeata, Tate	X	X	? X	X
Ranella Prattii, T. Woods	X	X	-	X
Triton cyphus, Tate	-	X	-	X
„ Woodsii, Tate	X	X	X	X
„ tortirostris, Tate	X	X	X	X
„ gemmulatus, Tate	X	X	-	X
Fusus acanthostephes, Tate	X	X	X	X
„ craspedotus, Tate	X	X	-	X
„ dictyotis, Tate	-	X	-	X
„ n.sp.	X	-	-	-
„ n.sp.	-	X	-	-
Latirofusus aciformis, Tate	-	X	-	X
Siphonalia longirostris, Tate	X	X	-	X
„ n.sp. aff. longirostris	-	-	-	-
Fasciolaria decipiens, Tate	X	-	-	X
Peristernia Morundiana, Tate	-	-	-	-
„ lintea, Tate	-	-	-	X

Fossils from Curlewis.	Belmont.	Schnapper Point.	Spring Creek.	Muddy Creek.
Peristernia n.sp.	-	-	-	-
„ n.sp. aff. crassilabrum	? X	-	-	-
Dennantia Ino, T. Woods	X	X	-	X
Zemira præcursoria, Tate	-	-	-	X
Phos, n.sp.	-	-	X ?	-
Voluta Hannafordi, McCoy (frag.)	-	X	-	X
„ ancilloides, Tate	-	X	X	X
„ McCoyii, T. Woods	? X	X	-	X
„ cathedralis ? Tate	-	-	-	X
„ antiscalaris, McCoy	X	X	-	X
„ strophodon, McCoy	X	X	-	X
„ n.sp. 1. aff. lirata	? juv.	-	-	-
„ n.sp. 2.	? juv.	-	X	-
„ n.sp. 3. aff. n.sp. Muddy Creek	-	-	-	-
† „ n.sp. 4. aff. conoidea	-	-	-	-
Lyria harpularia, Tate	X	X	-	X
Mitra alokiza, T. Woods	X	X	-	X
„ othone, T. Woods	X	X	-	X
„ atractoides, Tate	X	-	-	X
„ n.sp. aff. leptalea	-	-	-	-
Marginella Woodsii, Tate	-	-	-	X
„ propinqua, Tate	X	X	X	X
„ micula, Tate	X	X	X	X
„ Wentworthi, Tate	X	X	X	X
„ sub-Wentworthi, Tate	X ? frag.	X	-	-
† „ sp.	X	X	X	X
Ancillaria hebera, Hutton	-	-	X	X
„ semilævis, Tate	X	X	-	X
„ pseudaustralis, Tate	-	X	-	X
Columbella clathrata, Tate m.s.	X	X	-	X
† „ sp.	? X	X	-	-
„ sp. aff. clathrata	? X	-	-	-
Cancellaria Etheridgei, Johnston	X	-	X	-
„ caperata, Tate	X	X	-	-
† „ n.sp.	X	-	-	-
Pleurotoma paracantha, T. Woods	X	X	X	X
„ Claræ, T. Woods	X	X	-	X
„ sp.	X	X	X	X
„ sp.	-	-	X	-
Drillia, sp.	? X	? X	-	X
Mangilia bidens, T. Woods	X	X	-	X
„ sp.	-	-	-	X
† ? „ sp.	-	-	-	-
Bela sculptilis, ? Tate	-	-	X	X
„ sp. aff. sculptilis	-	-	-	-
Raphitoma n.sp.	-	-	-	-
Pusianella sp. aff. hemiothone	-	-	-	-
„ n.sp.	-	-	-	-
Daphnella tenuisculpta, T. Woods	-	X	-	X
Conus heterospira, Tate	X	X	-	X

Fossils from Curlewis.	Belmont.	Schnapper Point.	Spring Creek.	Muddy Creek.
Conus Dennanti, Tate	-	X	X	X
„ n.sp. aff. heterospira	-	-	-	-
Cypræa contusa, McCoy	-	X	-	X
„ pyrulata (?), Tate	-	X	-	X
„ brachypyga, Tate	X	X	-	X
„ leptorhyncha, McCoy	-	X	X	X
„ Mulderi, Tate	X	-	-	-
Trivia avellanoides, McCoy	X	X	X	X
† Semicassis transenna, Tate	-	X	-	X
Cassidaria gradata, Tate	-	X	-	X
Natica Hamiltonensis, T. Woods	X	X	-	X
„ polita, T. Woods	X	X	-	X
Crepidula sp.	-	X	-	-
† ? Scalaria sp.	-	-	-	-
Turritella Murrayana, Tate	X	X	-	X
„ sp.	X	X	X	X
„ sp.	X	X	-	X
„ sp.	X	-	X	-
Siliquaria squamulifera, Tate m.s.	X	X	-	X
Vermetus conohelix, T. Woods	X	X	X	X
„ sp.	X	X	-	-
Eulima sp.	? X	-	-	-
Niso psila, T. Woods	X	X	-	X
Odostomia sp.	X	-	-	-
„ sp.	X	-	-	-
Cerithium crebarioides, T. Woods	X	X	X	X
„ n.sp. aff. crebarioides	-	-	-	-
† Cerithiopsis n.sp.	X	-	-	-
„ n. sp.	-	-	-	-
Triforis Wilkinsoni, T. Woods	X	X	-	X
„ sp.	-	X	-	X
? Calliostoma sp.	-	-	-	? X
Delphinula aster, T. Woods	X	X	-	X
Fissurellidæa malleata, Tate	-	X	-	X
Hemitoma occlusa, Tate, m.s.	X	X	-	X
Emarginula cymbium, Tate, m.s.	-	X	-	X
† Scaphander fragilis, Tate, m.s.	X	X	-	X
† Ringicula sp.	X	X	-	X
Cylichna exigua, T. Woods	X	X	X	X
Class, Scaphopoda.				
Entalis Mantelli, Zittel	X	X	X	X
„ subfissura, Tate	X	X	X	X
Dentalium aratum, Tate	-	X	X	X
Class Cephalopoda.				
Nautilus sp. 1.	-	X	-	-
Nautilus sp. 2.=Gellibrand R. species	-	-	-	X
Class Pisces.				
† Otoliths	X	X	X	X

SUMMARY FOR LOCALITY 2.

Class.	No. of Species.
Actinozoa - - -	3
Echinodermata - -	1
Palliobranchiata - -	1
Lamellibranchiata - -	25
Gastropoda - - -	102
Scaphopoda - - -	3
Cephalopoda - - -	2
Total - - -	137

The following are the only previous records we have seen of fossils from this locality.

Prod. Pal. Vic., Dec. I., p. 28—*Voluta antiscalaris*, McCoy, recorded as "Common in the Tertiary Clays of A^{d}. 14, parish of Moolap."

Id. Dec. III., p. 38—*Trivia avellanoides*, McCoy "very rare and of small size in blue clay (A^{d}. 14) Outer Geelong Harbour."

Id. Dec. IV., p. 14—*Pecten Yahlensis*, T. Woods, "of large size A^{d}. 12;" also *id.*, p. 26—*Voluta strophodon*, McCoy, "Abundant in blue Oligocene Tertiary Clays of Moolap (A^{d}. 14)."

Id. Dec. VI., p. 40—*Lovenia Forbesi*, Duncan, "from Miocene beds of beach at Outer Geelong Harbour, (A^{d}. 12)."

Taking only the Mollusca proper from the two localities we have recorded 150 species distributed as follows:—

Class.	No. of Species.
Lamellibranchiata - -	25
Additional Lamellibranchiata from Locality 1. - -	8
Gastropoda - - -	102
Additional Gastropoda from Locality 1. - -	10
Scaphopoda - - -	3
Cephalopoda - - -	2
Total - - -	150

Of these 150 species only three are represented in living creation, which, therefore, gives us only two per cent. of living species. Several of the species however have not yet received specific names, but so far as the study of them has gone up to the present, it does not seem possible to refer any of them to living species.

By an inspection of the above list it will be seen to include many of our most characteristic Eocene fossils, and from the accompanying table the close relationship to other characteristic Eocene localities is obvious.

The fossils throughout the dark clays are in a very good state of preservation though the clays are very wet, and this which much increases their tenaceous character also greatly increases the difficulty in procuring specimens without damage, and it is of very little use to attempt to clean the specimens for purposes of identification until they have dried considerably.

A few remarks on some of the fossils might not be out of place. Two of the species namely, *Waldheimia divaricata*, and *Peristernia Morundiana*, have hitherto only been obtained from the River Murray Cliffs, and it is a very interesting fact to find them also in this locality. There can be no doubt whatever about these identifications, as they have been carefully compared with actual specimens from the typical locality.

Pecten dichotomalis is an interesting shell which is at present only recorded from Schnapper Point and the Gellibrand River and is not particularly common at either of these localities.

A new *Fusus* should be noted, examples of which have also been obtained from Schnapper Point. This remarkable shell will no doubt form the type of a sub-genus as it possesses such marked characters of its own, the whorls are wholly disjoined, the canal is almost closed, and the whole shell roughly speaking is somewhat like the columella of some fusoid shell divested of the whorls, the embryonic whorls are however in contact and are terminated by a projecting apex.

Some specimens of a new species of *Phos* were obtained which show strong affinities to the undescribed species occurring at Spring Creek, but owing to the fact that the Spring Creek examples are not in a very good condition nothing very definite about their identity can be said at present. The new species of

Voluta are worth mention. The first is a shell of the type of *V. lirata*, Johnston, but it differs from this species in many points, amongst others the absence of costæ is conspicuous.

The second shell is identical with a new species occurring at Spring Creek, which, in the adult form is quite seven inches in length with a characteristic long and slender spire terminated by an embryo with a markedly exsert tip.

The third, though an incomplete example, shows sufficient characters to designate it a new species with certain affinities to an undescribed species from Muddy Creek, which is related to *V. Stephensi*, Johnston, of Table Cape.

The fourth species belongs to the sub-genus *Volutoconus* and has its nearest ally in *V. conoidea*, but it is readily distinguishable from this species as the spire is much shorter and the whorls more tumid.

Cypræa Mulderi, Tate, is a shell we were not at all sorry to see turn up, as the only two examples previously found were obtained in sinking a deep well in Belmont. The type specimen is in the Adelaide University Museum and the second one is the property of Mr. Mulder of Geelong. Two additional examples were obtained.

A small and very pretty undescribed species of *Nautilus* turned up, which is apparently identical with the one occurring at the Gellibrand River and Muddy Creek.

The amount of disturbance in eocene strata as shown here is apparently unparalleled in Southern Australia and is evidently merely local. The polyzoal rock in M'Cann's quarry at Waurn Ponds dips S. 10° E. at 3° or 4°. The sandy limestones at Belmont, on the river bank just above Barwon bridge, dip E. 40° S. 10°. While between these two localities in the bed of the Waurn Ponds Creek, about 300 yards below where the Geelong to Colac road crosses it, the dip is N. 25° W. 7°. The Muddy Creek beds are stated by Mr. J. Dennant* to be horizontal, while Professor Tate, speaking generally of the Older Tertiaries of Southern Australia, says† that "for the most part secular elevation of the Older Tertiary sea bed has been of small amount and uniform."

* Trans. Roy. Soc. S.A., 1888, p. 33. † Proc. Roy. Soc. N.S.W., 1888, p. 241.

An instance of a high dip in older tertiary strata is however recently quoted by Mr. T. S. Hart* as occurring on the cliff-section near Mentone, and is given as S. 20° E. at 30°, with fractures and slight faulting. The rest of the section shows a very low dip, this high angle being noted in one fold only.

The high dip, contortion and the changed character of the small area of polyzoal rock exposed, point to subsequent volcanic disturbance, though no trace of igneous rock overlying the fossiliferous strata was found. Possibly no great discharge of solid material took place, but heated gases caused the slight metamorphism of the limestones.

The Clifton Mineral Springs, plentifully charged with carbonic acid gas, possibly represent the dying, or solfatara stage, of this outburst.

To the westward of the Curlewis section, the Bellarine Hills rapidly drop to the level of the plain, that separates them from the Geelong Hills, and the eocenes disappear from view. The upper tertiary beds are very thick and apparently form the greater part of the cliffs about the west end of the section, as the gully exposures gave no indication of the existence of any of the older beds, but showed mottled clays sands and conglomerates, and were, as far as we saw, unfossiliferous.

As almost the whole of the visible portion of the eocene beds of this section is exposed only between tide marks, advantage must be taken of low-tides to thoroughly examine the deposit, and this materially shortens the time available for work; besides which, only small portions of shells are visible above the surface as the pebbles and pyrites nodules soon destroy the projecting portions of the fossils. The clay beds, as at Mornington, are inhabited by great numbers of *Barnea australasiae* and *B. similis*. One peculiar feature of the beach is the manner in which the seaweed and shells are consolidated into a peaty mass, the pieces of wood enclosed looking like lignite.

A note on the ¼ sheet (23 S.W.) states that a shaft to the east of Fenwick's Gully showed 61 feet of ferruginous sands and clays overlying seven feet of black sandy clay with nodules of pyrites and fragments of lignite. This latter is called 'miocene,' presumably

* Vict. Nat., vol. ix., p. 157.

as it was thought to resemble the other plant beds of the colony which are ascribed to that age. Now these plant beds at Flemington, Berwick, Dargo High Plains and other places* where they are associated with the Older Volcanic rock, underlie it. However there are certainly good grounds for doubting the age ascribed to the volcanic rock. At Flinders, a small patch of polyzoal rock lies on the deeply eroded surface of the igneous series. The limestone being crowded with foraminifera such as Amphistegina (very common) Operculina and Orbitoides shows an approach in character to the Orbitoides limestone which we showed† lay at the base of the Moorabool Valley beds. At Eagle's Nest, near Airey's Inlet, the so called miocene also, as shown by the sections of the Survey, overlies the volcanic rock. Palæontological evidence is gradually accumulating to show that the ferruginous beds of Royal Park, near Melbourne, also belong to the eocene series, and these beds, as the cutting, for instance, in the park shows, lie also on the deeply eroded surface of the volcanic rock. Here at Curlewis, we show the same sequence. Selwyn‡ says that "the products of both volcanic periods are often contemporaneous, and interstratified, with the marine limestones." The only specific instances we can find quoted of this intercalation, in reference to the Older Volcanic, are the Maude sections on the Moorabool River, and Sutherland's Creek. As a rule then, there has been a considerable lapse of time between the volcanic flows and the deposition of the marine eocene beds. Should the Survey reading of the Maude section prove the correct one, some subdivision of the Older Volcanic series will be required, as a rock, the surface of which is deeply eroded before being covered with a marine deposit, can hardly be ascribed to the same age as a sheet intercalated with the latter. That the officers of the Survey have felt the need of some such division is shown by the legend attached to the older volcanic rock of the Bellarine Hills ($\frac{1}{4}$ sheets 23 N.E. and 23 S.E.) namely 'miocene or older.' That it certainly is older is shown by the fact that the clays which are marked as miocene on the map, but which were subsequently stated by Prof. McCoy to be Oligocene,§ distinctly overlie it. The lower tertiary beds of this

* Murray, Geol. and Phys. Geog. of Vict., p. 104, et seq.
† Proc. Roy. Soc. Vict., vol. iv., N.S., p. 11.
‡ Exhib. Essays, 1866, p. 31. § Prod. Pal. Vic., Dec. iv., p. 26.

area are clearly of the same age as the typical eocenes of Muddy Creek. The plant beds then must come in, either at the base of the eocene series, or may possibly be even of cretaceous age.

Professor Tate has already indicated his discovery in South Australia of beds containing plant remains, which were orginally referred to Miocene age, occurring in conjunction with marine Cretaceous fossils, giving us a somewhat parallel case to the famous Laramie Beds of North America. In the vicinity of Adelaide, beds containing carbonaceous matter are also known to occur directly underlying the Eocene Tertiary as proved by the Adelaide bore.

Plant beds are extensively developed in New South Wales, and Wilkinson* states that they show "a perfect resemblance to the Lower Miocene leaf beds of Bacchus Marsh in Victoria; some of the impressions in the form seem to be undistinguishable from the Victorian fossils." Some of the New South Wales plant beds have been referred by Baron von Ettingshausen† to eocene age, apparently solely based upon the plant remains themselves. The discussions on the age of the New South Wales coal series and of the Laramie Beds of North America, go to show that very little weight can be attached to the evidence afforded by terrestrial or freshwater forms of life. The evidence which has been obtained in South Australia and Victoria is of a more definite nature, and at present seems to point to the Cretaceous age of the older deposits containing plant remains.

From Clifton Springs to Lake Connewarre, the surface is covered everywhere with a thick mantle of Upper Tertiary rocks, consisting of clays, loose sands and quartz gravels. Along the lake margin, and extending some distance inland, ferruginous grits are the almost universal representatives of these beds. They are of a dark-brown hue, coarse grained, fairly hard, and afford the common road metal of the southern part of the district, About a mile N.E. of Drysdale occurs a coarse sandstone with a siliceous cement which is used as road metal near Portarlington. The quartz is glassy and in some cases shows crystalline faces. The rock is of a whitish colour, somewhat cavernous, the cavities being sometimes coated with limonite.

* Notes on the Geology of N.S.W., 1882, p. 56.

† Mem. Geo. Surv. N.S.W., Pal. No. 2. Contributions to the Tertiary Flora of Australia, 1888, p. 7.

From near the place at which the Barwon enters the lake, to the south end of Kissing Point, which is the Southern termination of Leopold Hill, basalt flanks the hill but does not rise much above the level of the lake. It is clearly a severed portion of the flow forming the plain to the south and west on the southern side of the lake. At Barwon Heads, the same rock is seen to be overlain by the Dune limestone of Mount Colite, and is referred on the ¼ sheet to Mount Duneed.

At the south end of Kissing Point, and overlying the basalt, occurs a bed of shells consisting of large oysters and *Barbatia trapezia.* It is about 20 feet above the lake level and is possibly a native shell-mound.

The great mass of the hill at this point is formed of a peculiar sandy limestone, in which no identifiable fossils could be detected. The officers of the Survey, in default of fossils, refer it doubtfully to miocene age. In appearance it somewhat resembles a dune limestone, though as we could not find a good section, we could not detect any false bedding in it. A similiar rock is marked as occurring at Bald Hill across the lake, but we did not visit it. We could not come to any conclusion about the age of this rock, but have not seen any eocene strata which resemble it closely.

From Campbell's Point to the north-west corner of the lake, gray clays constantly appear on the beach floor, and are overlain by yellow earthy limestone just above water level. Apparently the beds do not rise to any height on the cliffs as we saw no exposure anywhere.

Fossils from Point Campbell.

Class, Actinozoa.

Order, Zoantharia.

Balanophyllia Australiensis, Duncan.

Class, Polyzoa.

Numerous genera and species.

Class, Lamellibranchiata.

Ostrea sp.

Dimya dissimilis, Tate.

Nucula Atkinsoni, Johnston.

Limopsis Belcheri, Adams and Reeve.

Pectunculus laticostatus, Quoy and Gaimard.
Cucullæa Corioensis, McCoy.
Crassatella Dennanti, Tate.
Cardita polynema, Tate.
Chione sp. (?)
Corbula ephamilla, Tate.
„ pixidata, Tate.

Class, *Gastropoda*.

Triton Woodsii, Tate.
Fusus senticosus, Tate.
Fasciolaria exilis, Tate.
Dennantia Ino, T. Woods.
Dolichotoma atractoides, Tate, m.s.
Conus heterospira, Tate.
Cypræa sp. (? platypyga).
Natica polita, T. Woods.
Solarium acutum, T. Woods.
Turritella platyspira, T. Woods.
Vermetus conohelix, T. Woods.
„ sp.
Cerithium crebarioides, T. Woods.

Class, *Scaphopoda*.

Entalis Mantelli, Zittel.
„ subfissura, Tate.

Class, *Pisces*.

Otoliths.

FOSSILS FROM POINT CAMPBELL.

SUMMARY.

Class.	No. of Species.
Actinozoa - - -	1
Lamellibranchiata - -	11
Gastropoda - - -	13
Scaphopoda - - -	2
Pisces - - - -	1
Total - - -	28

From here to Fenwick's Gully, only Upper Tertiary beds were seen along the shore. On following up the gully the yellow earthy limestone, which forms the upper portion of the eocenes in the Geelong district, was seen outcropping frequently. It is overlain by a white earthy travertin, which is derived from it, and is burned for lime in the district. To the north of the Queenscliff Road, is a quarry on the side of the gully, which has for many years supplied the road with metal.

The hard rock occurs in narrow irregular bands, varying from a foot to a few inches in thickness. The rest of the deposit consists of yellow earthy limestone of a softer texture. The hard bands are composed of a fawn-coloured, granular, siliceous limestone which rings under the hammer and breaks with a clean sharp fracture. Sir Richard Daintree, who analysed it, states its composition to be as follows*.

Carbonate of lime	75·20
" " magnesia	3·00
Silica	15·79
Alumina and peroxide of iron ...	3·00
	96·99

The following are the fossils obtained from this locality, owing however to the very hard nature of the rock, it is a somewhat difficult matter to collect any number of specimens.

Placotrochus deltoideus, Duncan.
Lovenia Forbesi, Duncan.
Dimya dissimilis, Tate.
Marginella propinqua, Tate.
? Ancillaria sp.
Cypræa sp. (cast probably leptorphyncha).
Turritella sp.

From an inspection of the above list, the horizon to which these rocks belong will be readily recognised as eocene.

Between the mouth of the gully and Ocean Grove the ¼ sheet (29 N.W.) marks a continuous outcrop of lower tertiary strata. Although we followed the margin of the lake between these two

* Selwyn and Ulrich, Ex. Essays, 1866, pp. 35 and 73.

points, the time at our disposal was too short for any detailed examination, and we saw no exposure of these beds till we neared Ocean Grove. The hills are covered with a thick deposit of ferruginous grits, quartz gravels and mottled clays while still more recent deposits from the beach of the lake. Near Ocean Grove a well sinking on the flat showed that the earthy limestone lay at no great distance beneath the surface. The sea cliff gave a section showing an earthy sandy limestone varying in colour from yellow to brown and containing flakes of black mica. After spending considerable time in endeavouring to obtain some fossils from the limestone which crops out on the cliff-face just below the Coffee Palace, we managed to get *Terebratulina Davidsoni*, (Eth. fil.), fragments of Echinoderms and of a species of pecten.

The same rock crops out on the sandy shore of the beach below high water mark, and Mr. J. Bracebridge Wilson stated* that he has dredged up fragments of it at some distance off the shore here. Eocene fossils are occasionally washed ashore on tne beach a couple of miles west of Barwon Heads, where one of us has found about half-a-dozen specimens while gathering recent shells.

We have to express our indebtedness to the collecting of Mr. Mulder of Geelong for some of the information as regards the fossils from Belmont.

REFERENCES TO SKETCH MAP.

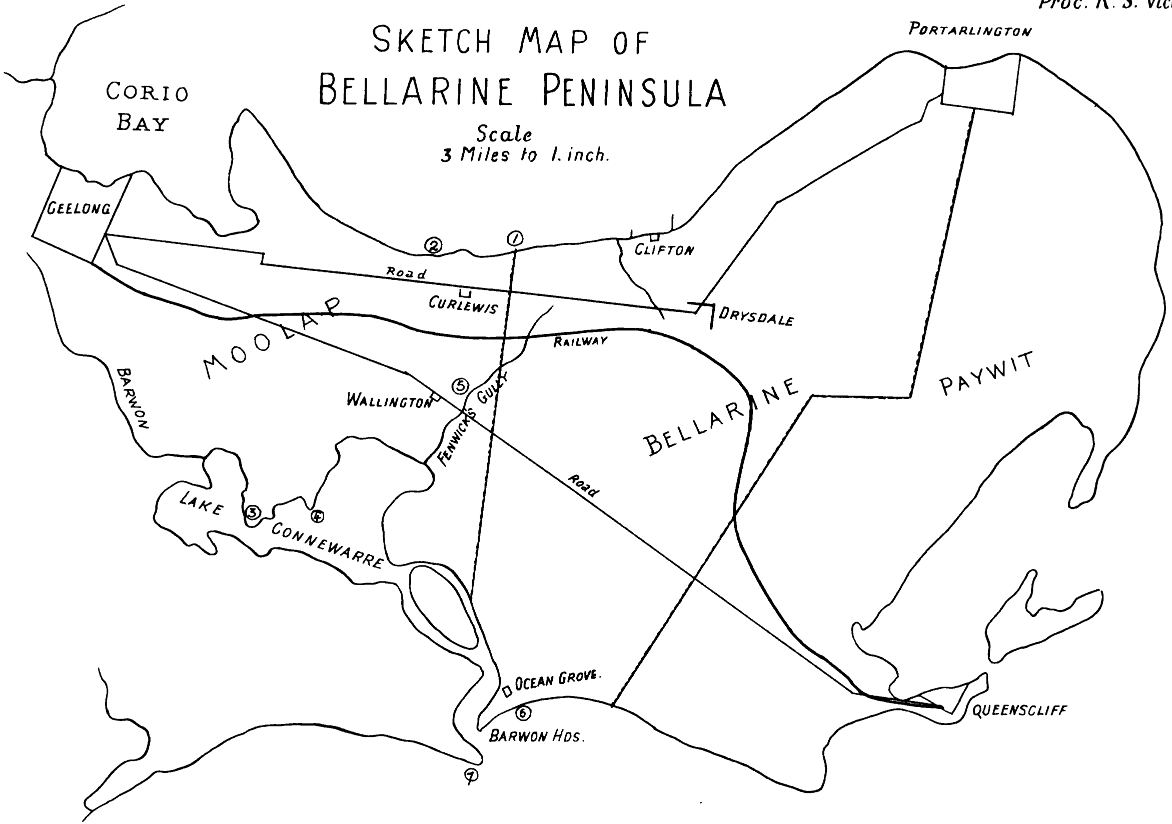
(Plate I).

1. Number 1 station. } The Curlewis section.
2. Number 2 station. }
3. Kissing Point.
4. Campbell's Point.
5. Quarry, Fenwick's Gully.
6. Cliff section, Ocean Grove.
7. Mount Colite.

* Proc. Roy. Soc. Vic., vol. iv., N.S., p. 221 (discussion).

SKETCH MAP OF BELLARINE PENINSULA

Scale
3 Miles to 1. inch.



ll 1893

[*Read at the Adelaide Meeting of the Australasian Association for the Advancement of Science, held September, 1893.*]

3

ON THE AGE OF CERTAIN PLANT-BEARING BEDS IN VICTORIA.

By T. S. HALL, M.A., and G. B. PRITCHARD.

In Victoria we have a series of deposits containing plant remains which have up to the present been generally regarded as of Miocene age. It is our present intention to bring forward a few facts concerning these beds which, in our opinion, seem to point to the necessity of altering the age to which they should be referred.

LOCALITIES.

In the vicinity of Flemington, not far from the old Model Farm, a deposit of white plastic clay, containing plant impressions, occurs, lying on the denuded surface of the Upper Silurian rocks, and underlying the so-called Older Basalt.

Similar clays, said to belong to the same horizon, are recorded* as occurring on the west side of the Melbourne swamp, near Footscray.

In Mr. Wilson's quarry, at Berwick, we have fine, somewhat indurated clays, for the most part of a dark color, yielding numerous plant impressions, underlying the Older Basalt, and resting on the Upper Silurian rocks. Mr. R. A. F. Murray remarks† that "there is no doubt as to the lignites of McKirley's Creek and the Tarwin, in Gippsland, being of Miocene age, because they are overlaid by older volcanic rocks." In these cases also the bed-rock is Upper Silurian. Ferruginous, sandy, and clayey beds, containing fossil leaves, occur beneath the basalt of the Cobungra High Plains. Similar beds also underlie the basalt of the Dargo High Plains and the Bogong High Plains.‡ At Bacchus Marsh ferruginous beds occur which contain numerous fossil leaves and fruits.§

At several localities in south-western and south-eastern Gippsland there are gravels, sandy beds, clays, lignites, and siliceous rock, ascribed to the same age as the beds above mentioned. They are generally found underlying the Older Basalt, though occasion-

* International Exhibition Essay, by R. Brough Smyth. 1873.

† Geo. and Phys. Geog., Vic., p. 105.

‡ Prog. Rep. Geo. Surv. Vic., No. v., p. 96, *et seq.*

§ Geology of District from Bacchus Marsh to Bass Straits, by R. Daintree, 1863; also, Geo. and Phys. Geog., Vic., Murray, p. 105.

ally they occur capping some of the hills which are surrounded, though not covered, by the volcanic rock, and are found resting on Upper Silurian and on Mesozoic (Carbonaceous Series).

For further particulars of these beds, see Progress Report of the Geological Survey of Victoria, No. III., p. 146, *et seq*; also No. V., p. 44-70.

The auriferous gravels of Hoddle's Creek, Upper Yarra, have yielded fossil fruits, and are overlain by the Older Basalt.

FOSSIL FLORA.

Cinnamomum polymorphoides (McCoy) occurs at Bacchus Marsh, the Cobungra, Bogong, and Dargo High Plains. (For description, see Prod. Pal. Vic., Dec. IV.)

Laurus Werribeensis (McCoy) occurs at Bacchus Marsh and Dargo High Plains. (See Prod. Pal. Vic., Dec. IV.)

Salisburia Murrayi (McCoy, MS.) occurs at the Dargo High Plains. (See Prog. Rep. Geol. Surv., No. V., p. 106.)

Lastrea Dargoensis (McCoy, MS.) occurs at the Bogong High Plains. (See Prog. Rep. Geol. Surv., Vic., No. V., p. 102.)

Tæniopteris tenuissime-striata (McCoy, MS.) occurs at the Bogong High Plains. (See Prog. Rep. Geo. Surv., Vic., No. V., p. 102.)

Spondylostrobus Smythii (F. v. M.), *Phymatocaryon Mackayi* (F. v. M.), *Celyphina McCoyi* (F. v. M.), *Conchotheca turgida* (F. v. M.), *Platycoila Sullivani* (F. v. M.), occur at the Tanjil, Gippsland.

The above fossils are described by Baron F. von Mueller in his papers on the New Vegetable Fossils of Victoria. They were first obtained from the Haddon gold drift, Ballarat, which is said to be of Pliocene age. We include them here because they are said to occur in deposits underlying the Older Basalt.*

Plesiocapparis prisca (F. v. M.) occurs at Hoddle's Creek, and is described along with the preceding.

Daphnogena sp., from Bacchus Marsh.

Acer (?) sp., from Bacchus Marsh.

Ficus sp., from Dargo High Plains.

REMARKS ON THE FLORA.

Respecting the fossils of the Miocene beds of Bacchus Marsh, Professor McCoy has reported as follows:—"The fossil plants of the ironstones are strikingly distinguished from the Pliocene Tertiary leaf-beds of the Daylesford and other older gold drift deposits by the total absence of myrtaceous plants, which so strongly mark the recent forest foliage of Victoria. I have no doubt the fossil leaves from this locality indicate a Lower Miocene or Upper Eocene Tertiary flora, in which lauraceous plants form a

* Geo. and Phys. Geog., Vic., Murray, p, 109.

remarkable feature. All the species seem new; but leaves of *Laurus*, *Cinnamomum*, *Daphnogena*, and possibly *Acer*, are scarcely to be distinguished from species referred to those genera in the leaf-beds (of the geological age mentioned) of Rott, near Bonn and Œnningen, especially the *Cinnamomum polymorphum* (Herr)." Professor McCoy also remarks*—"The specimens from this locality (head of the Bundarrah, *i.e.*, Bogong High Plains) are of great interest from containing a new species of *Tæniopteris*, *T. tenuissime-striata* (McCoy, MS.), the first example of this in Tertiary rocks in Australia, although well-known in rocks of this age in other parts of the world. There is also a *Lastrea*, *L. Dargoensis* (McCoy, MS.), allied to a Miocene species from the Arctic regions. With these are a few fragments of dicotyledonous leaves, apparently identical with some from Bacchus Marsh, but too imperfect for precise identification." The same authority, in the report above referred to, also remarks on specimens from the Dargo High Plains as follows:—"Several imperfect lauraceous leaves of undescribed species, occurring also in the Miocene Tertiary beds of Bacchus Marsh. With these is a most interesting specimen of a species of *Salisburia*, *S. Murrayi* (McCoy, MS.), nearly allied to some Miocene forms from the Arctic regions, but not hitherto found in Australian strata." Also, "The specimens are all clearly of Miocene Tertiary age, the *Cinnamomum polymorphoides* (McCoy) and *Laurus Werribeensis* (McCoy) being the only ones as yet described and figured, but several others are identical with forms in the Bacchus Marsh beds, bearing out my former suggestion of the geological identity of the deposits of these two localities. In addition to these are some imperfectly preserved impressions, apparently referable to the *Ficus Dionysia* (Massalongi) from the South European Miocene beds, and traces of at least two plants not previously observed."

AGE OF THE BEDS.

The apparent reason for determining these beds to belong to the Miocene age is a comparison of the fossil flora with that of Europe. Professor McCoy has stated that he has no doubt that the fossil leaves from Bacchus Marsh indicate a Lower Miocene or Upper Eocene Tertiary flora, but we are not aware of any subsequent reference to Upper Eocene age in any of the Victorian geological reports on these beds. As only a very few determined plants have as yet been recorded from the Victorian beds, any comparison with European Tertiary floras must have been of a somewhat slight nature. Then, with regard to the overlying basalt, the officers of the Geological Survey of Victoria determined the age of the so-called "Older Basalt" as Miocene, because they say they have observed it overlying marine Miocene beds, the latter said to have

* Prog. Rep. Geo. Surv., Vic., No. v., p. 175.

been determined upon their fossil contents. Mr. Murray remarks: —* "The older volcanic rocks are the latest products, and mark distinctly the close of the Middle Tertiary or Miocene era." In speaking of the basalt of the Dargo and Bogong High Plains, the same authority says:—† "The basalt or lava forming the high plains is here referred to the older volcanic (Miocene) period, immediately overlying, as it does, sedimentary deposits shown by their fossil flora to be of Miocene or Middle Tertiary age. Objection may be taken to this classification on the ground that the fact of basalt overlying Miocene deposits does not necessarily prove it to belong to that epoch; but the evidences here are to the effect that the Miocene beds were still in actual progress of deposition when the lava poured over them." At Curlewis, near Geelong, the Older Basalt is distinctly mapped and reported on by Daintree as overlying marine Miocene beds. Recently we had an opportunity of visiting this locality, and were surprised to find that the Older Basalt distinctly underlies the so-called Oligocene of the Survey. The fossils we obtained from these clays clearly indicate a lower horizon than Oligocene, most decidedly Eocene, and probably Lower Eocene, as the specimens were almost all identical with species occurring at the typical Eocene localities, such as Muddy Creek and Mornington‡; so that at this locality the "Older Basalt," with its upper surface showing considerable denudation, is clearly anterior to the deposition of the marine Eocene beds. This is also the case at Flinders, where an undoubted marine Eocene limestone rests on the denuded surface of the volcanic rock. On the Otway coast, at Eagle's Nest, a volcanic deposit is recorded, underlying Eocene beds (Miocene of Survey).§ Other localities showing the same sequence of the rocks have lately come under our notice.

Mr. Selwyn records|| a section on the Moorabool River, near Maude, where there is a band of older volcanic intercalated between marine Miocene beds, but we have not yet had an opportunity of visiting this locality, and so are not at present prepared to say anything further on it. Nowhere, so far as our observations have yet extended, have we observed the "Older Basalt" overlying or intercalated with the Eocene Series; so that from the evidence we have thus far adduced it can be clearly seen that the so-called "Older Basalt" of the localities mentioned is considerably older than it has hitherto been regarded, and, as there is a decided unconformity between it and the marine Eocene beds, which are now looked upon by some authorities as Lower Eocene, it is even probable that it may ultimately be found convenient to remove the basalt from the Tertiary Period.

* Geo. and Phys. Geo., Vic., p. 109. † Prog. Rep. Geo. Surv. Vic., No. v., p. 106.

‡ Proc. Roy. Soc., Vic., N.S., vol. vi.

§ Geological Map of the Cape Otway District; also, Geelong Naturalist, vol. ii., No. 8, p. 3.

|| Intercol. Exhib. Essay., 1866-67.

Professor Tate and Mr. Dennant, in their paper on the Correlation of the Marine Tertiaries of Australia,* make the following remarks, which have an important bearing on this part of our paper:—"This basalt rests directly upon Mesozoic strata at San Remo, on the eastern shore of Western Port, while at Flinders, on the west, it is overlain by the Eocene Tertiary. The "Older Basalt" is commonly called Miocene, because the strata overlying it were assumed to belong to that period. Instead of such being the case they are, as we have endeavored to prove, of Eocene age, and the epoch of the basalt must be correspondingly altered. It cannot be younger than Eocene, and may ultimately prove to be Cretaceous."

Previous to the publication of the above paper we had come to similar conclusions from independent observations in the Bellarine Peninsula and elsewhere, and had communicated our results to the Royal Society of Victoria at their first meeting for this year.

Now let us look at the evidence we can obtain from a brief examination of the plant remains themselves. Taking the genera above mentioned, which are based on the leaf remains, we find that their distribution confines our attention between the limits of Cretaceous, as represented in the Laramie Group of America and Miocene as represented in Europe. Mr. Lester F. Ward, in his "Synopsis of the Flora of the Laramie Group," gives a table of the distribution of Cretaceous and Eocene plants,† which bears out the above statement.

From our remarks on the "Older Basalt," and its unconformable marine Lower Eocene cover, it can be readily seen that the limits are narrowed down to the consideration of Cretaceous on the one hand and very early Eocene on the other.

GENERAL REMARKS.

There are a few points with regard to certain deposits in some of the other colonies which tend to a great extent as confirmation of the above.

Professor Tate has already indicated his discovery of a Cretaceous fauna mixed with a Tertiary flora, which was at one time regarded as Miocene,‡ from a locality near Lake Frome, in South Australia. We have in this a somewhat parallel instance to the famous Laramie beds of North America. In the latter case a comparison with European floras was made, but was found very unreliable in face of the evidence obtained from stratigraphical position and palæontological evidence based on marine forms.

* Trans. Roy. Soc. S.A., vol. XVII., pt. I., p. 212.

† U.S. Geol. Surv., 6th Report, 1885.

‡ Adelaide Philosophical Society, President's Address, 1879.

A peculiarity of lithological resemblance between some of the beds seems so marked a feature that it may be worthy of mention. In certain of the Victorian beds, particularly in the Gippsland district, a marked character is the presence of a siliceous cement, which has been suggested as probably due to hydrothermal action.* Certain Upper Cretaceous rocks of Queensland and South Australia are mentioned by some authors as being characterised by the occurrence of a similar cementing material.

The late Mr. C. S. Wilkinson has remarked on the apparent identity of certain plant-bearing beds of New South Wales with the Victorian beds in the following terms :—† "In many places on the Great Dividing Range and at various elevations up to 5,000ft. above the sea occur beds of conglomerate, siliceous sandstones, clays, and ironstones, containing impressions of leaves. In lithological character these beds have a perfect resemblance to the Lower Miocene leaf-beds of Bacchus Marsh in Victoria; some of the impressions of leaves in the former seem to be undistinguishable from the Victorian fossils."

Baron von Ettingshausen, in dealing with similar material to that which occurs in the Victorian beds from Dalton, near Gunning, New South Wales, regards the fossil flora from that locality as Eocene, the classification being apparently based upon the plants themselves.‡ The same authority, in dealing with the fossils from Vegetable Creek, comes to the conclusion upon the same somewhat precarious method, that that fossil flora might be referred to Lower Eocene, from the European point of view.§ At the same time he draws attention to the close affinity of some of the forms to those usually belonging to the Cretaceous Period, but does not seem to lay very much stress upon them, as he says—‖ "Examples indicating the attachment of our flora to that of the Cretaceous Period appear, however, to be only isolated when we take into consideration its numerous analogies to real Tertiary plants."

We have shown that the age of the Victorian leaf-beds has been brought within comparatively narrow limits, and if Mr. Wilkinson's comparison holds good, and is still borne out when more is known of the various species occurring in the Victorian beds which have not yet received any attention, is it not possible that the New South Wales beds also may require to be placed further back in time?

* Prog. Rep. Geol. Surv., Vic., No. III., page 148. † Notes on the Geology of New South Wales, 1882, p. 56.

‡ Contributions to the Tertiary Flora of Australia, pp. 8, 9.

§ *Id.*, p. 77 *et seq.* ‖ *Id.*, p. 80.

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Royal Society of Victoria.

THE OLDER TERTIARIES OF MAUDE, WITH AN INDICATION OF THE SEQUENCE OF THE EOCENE ROCKS OF VICTORIA.

By T. SERGEANT HALL, M.A. (Assistant Lecturer and Demonstrator in Biology in Melbourne University),

and

G. B. PRITCHARD (Lecturer in Geology, Workingmen's College, Melbourne).

Ford & Son, Printers, 372 & 374 Drummond Street, Carlton, Melbourne.

Art. XVII.—*The Older Tertiaries of Maude, with an Indication of the Sequence of the Eocene Rocks of Victoria.*

By T. Sergeant Hall, M.A. (Assistant Lecturer and Demonstrator in Biology in Melbourne University),

and

G. B. Pritchard (Lecturer in Geology, Workingmen's College, Melbourne).

[Read 13th September, 1894].

The sections of the tertiary rocks displayed in the valley of the Moorabool River, near Maude and to the northward, were early recognised as throwing considerable light on the correlation of beds which are separately better developed elsewhere. In 1866 Sir Alfred R. C. Selwyn reported to Parliament* on the age of the Victorian gold drifts, and the report was, in the following year, reprinted by him with reduced copies of the sections therein contained in the Exhibition Essays.†

On the evidence there detailed, the older volcanic rocks, the plant beds underlying them and certain non-auriferous gravels occurring in the neighbourhood of Maude, and elsewhere in the colony, were referred to the miocene of the survey, that is to our eocene. Mr. C. S. Wilkinson, assisted by Mr. R. A. F. Murray, made a minute geological survey of a part of the district, and the quarter-sheet (19 S.W.) which includes the most important part of the area, was published in 1865. Unfortunately the sheet of sections and explanatory notes, which should have accompanied the map, has never appeared. The results of our observations on the eocene bed at Curlewis‡, rendered it advisable that an early visit should be paid to the Maude district, and a recent vacation has afforded us the desired opportunity.

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* Votes and Proceedings of the Legislative Assembly of Victoria, 2nd Session, 1866, vol. i.

† Exhibition Essays, 1866-67, pp. 21-26.

‡ Proc. Roy. Soc. Vic., 1893, p. 18.

The eocene rocks occupy an area of slightly elevated ground flanking the ordovician rocks which extend south from Steiglitz. To the east, south, and west, the country is covered by an almost unbroken sheet of what is generally called the "Newer Volcanic Rock." The surface of the exposed eocene rises slightly above the level of the basaltic plain, and the geological boundary is marked on the west by the valley of the Moorabool River, and on the east by that of Sutherland's Creek, the two streams meeting a little to the south of the area. The eocene beds underlie the basaltic plains and are exposed wherever the streams have cut through the overlying rock, which extends from Port Phillip to beyond Hamilton in the west. The valleys of the two streams above alluded to are very striking features in the district. Aneroid measurements showed their depth to be about 250 feet in each case, and the Moorabool Valley averages about a mile in width, while that of Sutherland's Creek is slightly narrower. It is in the sections displayed along these steep sided valleys that the geology of the district can best be studied.

The bed rock of the immediate neighbourhood is ordovician, but granite outcrops frequently between the Anakie Hills and the Dog Rocks, near Geelong, both of which are composed of this rock. Aided by the quarter-sheet, we examined all the marine eocene outcrops we could find, and a description of the more instructive sections will make the structure of the district clearer.

On the Moorabool, a section line is indicated on the map crossing the valley, and passing through an outcrop of limestone underlying the older volcanic rock. This line we examined carefully. The surface soil on the east of the valley is very sandy, so that there is at first a very gradual descent towards the stream. The section is approximately as follows :—

EOCENE—		
Sandstone passing down into limestone	? 40	feet.
Limestone	10	,,
Older volcanic	120	,,
Sandy limestone and conglomerate ...	30	,,
ORDOVICIAN—		
Slates and sandstones	40	,,
	240	feet.

The sandstone capping the hill covers the whole of the area between the two streams, excepting in one or two places where an outlier of newer volcanic rock overlies it, or where minor valleys have cut through it. It gradually passes down into limestone which is in places largely composed of polyzoa and echini spines. The base of the limestone rests on the surface of the basalt, which, though approximately level when taken as a whole, is carved into steep and irregular depressions. The lower part of the limestone is full of well rounded basalt fragments, from mere pebbles up to blocks of great size. Close to the junction, and extending up from it for a variable distance in the different sections, the limestone is altered to a hard pink crystalline rock, which is described by Professor Sir F. McCoy as in some places "closely resembling lithographic stone."*

This rock is full of fossils, but for the most part they exist as casts only. They consist of trochiform shells, haliotis, cerithium, and such forms as to-day live on the rocky, bouldery parts of our coasts. That the Maude fossils are littoral forms has been pointed out by Sir Fredk. McCoy.† The talus blocks of this hard limestone are thickly strewn over the slopes below the outcrop, and dozens of specimens, picked up at random and broken with the hammer, displayed, in nearly every instance, rounded fragments of basalt embedded in the mass. In no single section did we find any evidence of the intercalation of a thin sheet of basalt. We inspected every outcrop we could find, and they were many, and followed the valley some distance south of the boundary of the quarter-sheet into unmapped country, but could find no sign of the basalt which is represented on the map as overlying the limestone, and as being in its turn overlain by other "miocene" (eocene) beds. The numerous small quarries for limestone showed over and over again, rounded pebbles and blocks of basalt scattered through the rock. As we go up from the basalt we find the limestone becoming less and less altered, till it assumes the character of the ordinary polyzoal rock, that is a rock of which the well-known Waurn Ponds building-stone may be taken as the lithological type. In this comparatively unaltered rock basalt fragments occur, but are not as numerous

* Prod. Pal. Vic., Dec. III., p. 24. † *Id.* p. 26.

as in the lower portion, and are often associated with small quartz pebbles. In a section displayed on the roadside between the State School and the old mill, at The Clyde, we measured one embedded basalt block exposed, and found it ten feet long and four feet thick. Another boulder was five feet by three feet six inches; and these great masses were associated with numerous fragments of all sizes, down to small pebbles; and all were well rounded. Packed in between the boulders was a deposit of comminuted polyzoa, broken and worn spines of echini, fragments of brachiopod shells and of pectens, but perfect specimens of any kind were rare.

It may be that the officers of the survey felt the necessity of accounting for the alteration of the rock to a crystalline limestone by igneous action, and were led to attribute it to an intercalated flow, taking the large included blocks as portions of such a sheet. The subsequently opened sections, however, dispose entirely of such an interpretation. On the opposite side of the river from this Clyde section, a large quarry is a conspicuous object on the hillside. This shows a clean face of nearly thirty feet, and is about fifty yards in length. The limestone, which forms the greater part of the quarry floor, rests on a very uneven basaltic surface, and extends about ten feet up the face. It is distinctly less altered as we go up from the volcanic rock, and is capped by arenaceous and calcareous beds, which reach apparently to the top of the hill. The cause of the change in character has, then, evidently acted from below, and is not due to a more recent flow of basalt. What this cause may have been is not clear to us, but we have recorded a similar alteration in the polyzoal rock overlying the ash beds of Curlewis.* Mr. D. Avery, M.Sc., has kindly examined the rock for us, and says there is only a very small amount of magnesia present, so that the changed character has not been brought about by dolomitisation.

Wherever the limestone is unaltered it is seen to be, both lithologically and palæontologically, the equivalent of that of Waurn Ponds.

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* Proc. Roy. Soc. Vic., 1893, p. 3.

COMPARATIVE TABLE BETWEEN UPPER MAUDE BEDS, AND WAURN PONDS.

Name of Specimen.	Upper Maude Beds.	Waurn Ponds.
ZOANTHARIA.		
Placotrochus elongatus, Duncan	-	X
Notocyathus australis, Duncan	X	-
Balanophyllia australiense, Duncan	X	-
Graphularia senescens, Tate	-	X
Isis, 2 spp.	-	X
ECHINODERMATA.		
Echinobrissus vincentianus, Tate	X	-
Echinobrissus australiæ, Duncan	-	X
Echinobrissus n. sp. ?	-	X
Paradoxechinus novus, Laube	X	-
Echinolampas posterocrassus, Gregory	†X	X
Psammechinus Woodsii, Laube	†X	X
Scutellina patella, Tate	†X	X
Schizaster abductus, Tate	‡X	-
? Toxobrissus sp.	X	X
Pericosmus Nelsoni, McCoy	-	X
Eupatagus murrayanus	-	X
Holaster australis, Duncan	-	X
Cyclaster archeri, T. Woods	-	X
Cidaroid plates and spines	X	X
CRUSTACEA.		
? Balanus sp.	X	X
Crab remains	X	-
POLYZOA	Abundant	Abundant
PALLIOBRANCHIATA.		
Waldheimia furcata, Tate	X	X
Waldheimia grandis, T. Woods	X	X
Waldheimia insolita, T. Woods	-	X
Waldheimia tateana, T Woods	X	-
Waldheimia corioensis, McCoy	-	X
Waldheimia garibaldiana, Davidson	-	X
Terebratula vitreoides, T. Woods	-	X
Rhynchonella squamosa, Hutton	X	X
Terebratulina scoulari, Tate	X	X
Magasella compta, G. B. Sowerby	X	X
Crania quadrangularis, Tate	X	X
Terebratella n.sp. aff. pentagonalis	X	-
Terebratella (?) sp. nov.	X	-
LAMELLIBRANCHIATA.		
Ostrea sp.	X	X
Placunanomia ione, Gray	-	X
Dimya dissimilis, Tate	X	X
Pecten foulcheri, T. Woods	X	X
Pecten murrayanus, Tate	-	X
Pecten polymorphoides, Zittel	X	-

Name of Specimens.	Upper Maude Beds.	Waurn Ponds.
Pecten yahlensis, T. Woods var. semilævis, McCoy	-	X
Pecten subbifrons, Tate	-	X
Pecten gambierensis, T. Woods	-	X
Pecten n.sp. aff., Eyrei	-	X
Lima Bassii, T. Woods	X	-
Limatula Jeffreysiana, Tate	X	-
Limatula crebresquamata, Tate M.S.	-	X
Spondylus pseudoradula, McCoy	X	X
Lucina n. sp.	X	-
Gastropoda.		
Triton tortirostris, Tate	X	-
Triton n.sp.	X	-
Voluta sp. (pullus)	X	-
Ancillaria pseudaustralis, Tate	X	-
Drilla 3. spp.	X	-
Conus heterospira, Tate	X	-
Cypræa spp. (casts)	X	X
Cypræa sp. (cast of a very large species, probably *C. gigas*)	X	X
Natica Mooraboolensis, Tate	X‡	-
Thylacodes conohelix, T. Woods	X	X
Thylacodes n.sp.	X	-
Niso psila, T. Woods	X	-
Cerithium Flemingtonensis, McCoy	X	-
Cerithium sp.	X	-
Triforis, sp.	X	-
Liotia sp. aff. Roblini	X	-
Tinostoma n.sp.	X	-
Turbo ? n.sp.	X	-
Opercula of Trochoid shells	X	-
Pleurotomaria tertiaria, McCoy	X§	-
Haliotis Mooraboolensis, McCoy	X§	-
Haliotis ovinoides, McCoy	X§	-
Scutus anatinus, Donovan	X‡	-
Pisces.		
Carcharodon megalodon, Agassiz.	-	X
Carcharodon angustifrons, Agassiz.	-	X
Lamna sp.	-	X
Oxyrhina sp.	X	X
Palate aff. Diodon.	-	X
Mammalia.		
Ziphius (Dolichodon) Geelongensis, McCoy	-	X§
Squalodon Wilkinsoni, McCoy	-	X§
Cetotolites Leggei, McCoy	-	X§
Cetotolites Nelsoni, McCoy	-	X§
Cetotolites Pricei, McCoy	-	X§

NOTE.—Those marked § have been recorded by Sir F. McCoy, and ‡ by Professor Ralph Tate, and those marked † have been shown us by the Rev. A. W. Cresswell, M.A., who informs us he collected them from the locality indicated.

SUMMARY.

——	Upper Maude Beds.	Waurn Ponds.
Zoantharia - -	2	4
Echinodermata - -	8	11
Crustacea - - -	2	1
Palliobranchiata - -	9	10
Lamellibranchiata -	8	11
Gastropoda - -	26	3
Pisces - - -	1	5
Mammalia - -	—	5
Total - -	56	50

An inspection of the list of fossils from the Upper Maude Beds, and from Waurn Ponds, brings out the close relationship existing between them. The most noticeable difference is caused by the presence of gastropods in the former beds, but it should be noted, that nearly the whole of these were obtained from the section above mentioned, near the Clyde, on the east bank of the river, and from a deposit overlying the polyzoal rock. This overlying deposit really represents the clays occurring at the Filter Quarries, at Batesford*, where the majority of these gastropod species are well represented. The deposit is of a very peculiar nature, and at first sight looks like a sandy clay full of brown pisolitic ironstone pebbles. A closer inspection and the use of the acid bottle, show that it is really a calcareous clay, and that the supposed ironstone pebbles are nearly all recognisable as casts of fossils. Some of these preserve the external form, while others are merely internal casts. Gastropods, echinus spines and polyzoa are all found thus preserved, and the ornamentation of the mollusca is frequently well-shown. All the casts are highly glazed, and of a dark brown colour. They are easily separable

* See below, p. 193.

from the matrix, and are readily crushed between the fingers. It is then found that the ferruginous coat is very thin, and surrounds an earthy internal part of a light fawn colour, similar to the matrix in which the casts are embedded. We have not seen anything comparable to this method of fossilisation, and are at a loss for an explanation of the processes which have brought it about.

The older volcanic rock in the district is much decomposed, and towards its upper part is full of amygdules of carbonate of lime, while some lumps of radiating crystals of arragonite, about half-a-pound in weight, were found on the slopes. The soil produced from the decomposition of the basalt is very fertile, and the valley was formerly noted for its vineyards, which have, however, now entirely disappeared, having been uprooted when *phylloxera* was prevalent in the district some years ago.

Below the older basalt in the first section indicated, we find, as shown on the map, another outcrop of limestone, which is very variable in its composition. As a rule, it is arenaceous and earthy, and is in places full of casts while actual fossils are scarce. When they were obtained they were so encrusted with a strongly adhering calcareous coat that while we were gathering them we were rarely able to recognise them specifically, and were consequently quite in the dark as to the equivalence of the beds, especially as one of the commonest forms was a new species of *Trigonia*. There can however be no doubt, as an examination of the faunal list will show, that the limestone represents the lower portion of the Spring Creek section. As we approach the base of the limestone, fragments of slate and quartz make their appearance, and gradually become more abundant, till at length we find the limestone has disappeared, and a conglomerate of well-rounded pebbles has taken its place. In the limestone and conglomerate basalt pebbles are conspicuous by their absence, although we spent some time in a careful search for them. This fact, together with the considerable extent of the outcrop, its evident bedding, and the great change in fauna, precludes the idea of its being a talus. We did not, it is true, see the actual junction of limestone and overlying basalt; but, unhesitatingly, agree with the interpretation of Messrs. Selwyn, Wilkinson and Murray as regards their relationship.

This section then settles the age of the older volcanic rock. It is eocene. In a paper, read by ourselves, on 9th March of

last year* we stated that it would seem advisable to refer the older volcanic rock to two distinct periods, should it be found that it was anywhere intercalated with eocene rocks, as we showed that it was in some cases overlain by beds which had been referred to lower eocene. At a later date† we suggested that it might be found advisable to remove it altogether from the tertiary period. Messrs. Tate and Dennant, subsequently to our first paper,‡ stated that the older volcanic rock "may ultimately prove to be cretaceous;" while Professor Tate, in the tabular view of the Tertiary Strata of Australia, as given in his Presidential Address before the Adelaide Meeting of the Australasian Association, puts the older volcanic rock under the head of pre-eocene, while, by a strange oversight, the leaf beds underlying it are referred to the eocene period. There is, we now think, not sufficient evidence to suggest a subdivision of the volcanic rock, and certainly none for considering its age anything but eocene.

Fossils from Lower Beds at Maude.

Zoantharia.

Placotrochus elongatus, Duncan.
Notocyathus australis, Duncan.
Bathyactis discus, T. Woods.

Echinodermata.

Maretia anomala, Duncan.
Monostychia sp.
Fibularia gregata, Tate.
Fibularia n.sp. (?)
Scutellina patella, Tate.

Annelida.

Serpula sp.

Polyzoa.

Well represented.

Palliobranchiata.

Magasella compta, G. B. Sowerby.
Terebratulina Scoulari, Tate.
Rhynchonella squamosa, Hutton.
Crania sp.

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* Proc. Roy. Soc. Vic., 1893, p. 1.
† Proc. Austr. Ass. Adv. Sci., Adelaide Meeting, p. 342.
‡ Proc. Roy. Soc. S. Aust., 1893, p. 212. Read 2nd May, 1893

Lamellibranchiata.

Ostrea sp.
Dimya dissimilis, Tate.
Pecten consobrinus, Tate, var.
Pecten Foulcheri, T. Woods.
Limopsis insolita, G. B. Sowerby.
Limopsis Belcheri, Adams and Reeve.
Pectunculus Cainozoicus, T. Woods.
Cucullæa Corioensis, McCoy.
Trigonia n.sp. aff. semiundulata.
Cardita n.sp.
Lucina leucomomorpha, Tate.
Dosinia Johnstoni, Tate.
Myadora tenuilirata, Tate.
Corbula pyxidata, Tate.

Gastropoda.

Turritella conspicabilis, Tate.
Mathilda transenna, T. Woods.
Rissoina sp.
Tinostoma sp.
Solariella sp.
Cylichna exigua, T. Woods.

Scaphopoda.

Entalis subfissura, Tate.

Pisces.

Otoliths.

SUMMARY.

Zoantharia	3
Echinodermata	5
Annelida	1
Palliobranchiata	4
Lamellibranchiata	14
Gastropoda	6
Scaphopoda	1
Pisces	1
	35

In the mollusca proper of the above list there are only three which have not hitherto been recorded from Spring Creek, namely, one lamellibranch which is a new trigonia, the diagnostic characters of which will be published shortly, and two gastropods. With regard to the representatives of the other classes, the majority also occur at Spring Creek, or in beds belonging to an equally low horizon in the tertiary series. This obviously shows the close relationship existing between the Lower Maude and Spring Creek beds. Upon stratigraphical grounds the Lower Maude beds are evidently very low down in the tertiary series. Our previous work in the Geelong district had led us to suspect that this was also the case at Spring Creek.

If we look at the results to be obtained from a critical examination of the Spring Creek fossils we have satisfactory confirmation of the above.

Messrs. Tate and Dennant, in their correlation paper,* record 227 species of mollusca, of these we are only able to pick out three living species which gives *a percentage of 1.3*. One of the above living species, namely, *Nucula Grayi, D'Orbigny* [= *Nucula tumida, T. Woods*] is, however, not recognised as such by Professor Tate This identification has been made on a careful comparison of the living shells, dredged in Port Phillip Bay, with our fossil species. We have been able to add sixty-six molluscan species to the above referred to paper, making a total of 293, without increasing the number of living species, so that it seems perfectly safe for us to assert that the *percentage of living species in these beds is one*, or at most, very slightly over.

As the older basalt overlies beds of this horizon, and is overlaid unconformably by limestones of the Waurn Ponds type, and clays of the Lower Muddy Creek or Mornington type, the two latter conforming to one another with a gradual change in sediment where a junction is seen,† it will be of interest and importance to examine the results of the percentage theory as applied to the Muddy Creek beds. Messrs. Tate and Dennant, in the paper above referred to, state:—"Out of a total of 725 species of all classes from the two well-marked zones at Muddy Creek, 511 have been definitely traced to the lower beds. Of

* Trans. Roy. Soc. S.A., 1893.

† Proc. Roy. Soc. Vic., N.S., vol. iv., p. 11.

these, from six to eight still survive, and the percentage of recent to extinct forms is thus about one and a half." In the list of fossils appended to Messrs. Tate and Dennant's paper, there are only 250 mollusca from Muddy Creek, which is obviously incomplete. Mr. Dennant, in a much earlier paper,* refers 405 species of mollusca to the lower zone. There are at least *ten recent species* now known from these beds which gives a *percentage of nearly two and a half.* It is not quite clear whether the 511 species mentioned above is intended to indicate mollusca only, but even if this should be the case, as is likely, we would still have nearly two per cent. of living species, which decidedly indicates an horizon younger than the Spring Creek beds, and is confirmatory of the stratigraphical sequence already indicated.

The section at North Belmont shows a resemblance to the Spring Creek beds in the occurence of:—*Cucullaea Corioensis, McCoy, Trigonia semiundulata, McCoy, Chione Pritchardi, Tate m.s.*, and *Chione cainozoica, T. Woods*, and some common forms of echinoderms and palliobranchs, and may tentatively at least be placed on the same horizon until more evidence is forthcoming.

According to Sir Alfred Selwyn,† the beds containing plant remains pass under the marine tertiaries to the north of Maude, but our stay was too short to allow us any time for examining the evidence on this point. In the sections on Sutherland's Creek, to the eastward of the first sections we mentioned, we find the ordovician rocks overlain by nearly 100 feet of quartzite and sandstones. The grain of this rock is fairly fine, and we found no trace of gravel or conglomerate in the beds. The change from loose sand into fairly compact sandstone, and then into quartzite seems very irregular. At the point where the ordovician is lost sight of as we go south, the overlying series consists of a white or brown rock on which the hammer makes but little impression, so that the alteration has been effectually carried out. In some places higher up the stream the quartzite may be traced up to the top of the deposit, whilst in others, the upper part consists of loose sand. It is not quite clear whether the beds are the equivalents of the lower limestone of the Moorabool Valley above described, or of the plant beds, though the latter seems more probable.

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* Trans. Roy. Soc. S.A., 1888, p. 39, *et seq.*

† Exhibition Essays, 1866-67, pp. 21, *et seq.*

With regard to the occurrence of a quartzite in the tertiary series, Professor J. W. Dawson, in speaking of one overlying the eocene in Egypt, uses words which exactly apply to our rock.* "The Red Mountain, near Cairo, . . . is composed of a hard brown, reddish and white sandstone . . . In many parts it has the characters of a perfect quartzite, and appears at first sight extremely unlike a member of the tertiary series . . . The induration of the beds seems to be local, and to be connected with certain fumarole-like openings, which have probably been outlets of geysers or hot siliceous springs contemporaneous with the deposition of the sand." Perhaps the same cause has been efficient at Maude. A somewhat similar tertiary quartzite, it it may be mentioned, occurs at Keilor, but is higher in the series, and is capped by newer and not by older basalt.

Overlying the quartzites of Sutherland's Creek, we have the older volcanic rock, and over this again limestone of a similar nature to that already described in the previous section. On the eastern side of the valley this is in some places capped by the newer volcanic rock. Near the most southerly outcrop of the ordovician on Sutherland's Creek we found the section to be, approximately, as follows :—

Newer volcanic	...	...	40 feet.
Sandy limestone	...	...	20 "
Older volcanic	...	...	60 "
Quartzite and sandstone		...	90 "
Ordovician slate	...	...	40 "
			250

The Sequence of some of the Victorian Eocene Beds.

The recognition of the fact that the sandy limestone underlying the older basalt of Maude, is practically the equivalent of the lower part of the Spring Creek section, and that the upper beds at Maude are the representatives of those at Waurn Ponds, supplies a hint that is of use in unravelling a good deal of the stratigraphical sequence of the eocenes, and we have gathered together a few facts which show that we are now in a position to

* Geol. Mag., N.S., Dec. III., vol. i., 1884, p. 385.

do something towards a better understanding of the deposits. That there are different horizons is what we should expect to find, and though lithological and bathymetrical conditions will constantly have to be kept in view as affording some explanation of differences in the faunas of different localities, still to ascribe everything to this and to "colonies," is surely asking more than is likely to be granted. An examination of the published lists of fossils from the lower beds of Muddy Creek,* Mornington, Gellibrand, and Camperdown,† Lower Moorabool Valley (Fyansford, etc.),‡ Belmont and Curlewis,§ Bairnsdale,‖ will show that these beds are on much the same horizon, though the exact relationships are not yet definitely fixed. No lists have been published for Corio Bay, Altona Bay, Newport, or Murgheboluc, but our knowledge of the desposits enables us to refer them to the same series, as the number of fossils at present known to us from these localities is as follows :—

Corio Bay	...	...	150 species.
Altona Bay	...	...	70 „
Newport	...	...	115 „
Murgheboluc	...	...	102 „

From Shelford we have over one hundred and fifty species, gathered by Messrs. Donald Clark, Betheras, and Alex. Purnell, which show that this deposit also may be referred to the same group.

We have shown that the clays at Curlewis¶ overlie a polyzoal limestone similar, lithologically, to that of Maude, and the same is the case at Batesford.♥ With regard to the latter place, it may be mentioned as a further confirmation of our previous reading of the section, that the work carried on at the "Filter Quarries" has displayed a face showing the limestone capped by about ten feet of eocene clay, rich in fossils, together with a thin clay band

* Trans. Roy. Soc. S. Aust., 1888, pp. 40-52.

† *Id.*, 1893, pp. 218-26.

‡ Proc. Roy. Soc. Vic., 1891, pp. 18-26.

§ *Id.*, 1893, pp. 10-13.

‖ Proc. Roy. Soc. Vic., 1890, p. 67. For most of these localities see also "Remarks on the Tertiaries of Australia; together with Catalogue of Fossils"—South Australian School of Mines and Industries, Adelaide, 1892.

¶ Proc. Roy. Soc. Vic., 1893, p. 3.

♥ *Id.*, 1891, p. 11.

intercalated with the upper part of the limestone. This clay is remarkable, chiefly for the great preponderance of trochiform shells, but otherwise resembles the section described by us on the other side of the valley.

There is little doubt that the polyzoal limestones of Waurn Ponds, Maude, Curlewis, and Batesford, are on the same horizon, though slight differences in the faunas certainly exist.

At Flinders and at Airey's Inlet,* at Curlewis and at Maude, a polyzoal rock rests on the older basalt. This in its turn, at Maude, overlies a sandy limestone containing a fauna which is the equivalent of that of Spring Creek. At Waurn Ponds the limestone overlies a clay in which fossils have not as yet been found, but which Mr. Wm. Nelson states† to closely resemble that of Spring Creek.

The Waurn Ponds rock can be traced almost uninterruptedly from M'Cann's quarries, which is the best known exposure, as far as a quarry on the south side of the Barwon River opposite the end of Pakington Street, Geelong. The locality of this quarry we shall indicate by the name of North Belmont. The rock here is a sandy limestone, and the fauna shows a stronger relationship to that of Spring Creek on account of the greater number of mollusca which it contains; though, unfortunately, most occur merely as casts. The dip of the beds is well pronounced being E. 40° S. at 10° This would carry them below the Belmont clays shown in the oft quoted well,‡ and Mr. J. Mulder informs us that limestone was struck at the bottom of the shaft after passing through the clay beds.

The polyzoal rock then appears to be antecedent to the clays of the Lower Muddy Creek type, and to overlie beds with a fauna similar to that of Spring Creek.

It will be seen that we almost entirely reverse the sequence as interpreted by Professor Sir Fredk. McCoy, and adopted by the Geological Survey. According to this view the clays of Mornington, Southern Moorabool Valley (Fyansford, etc.), and

* Proc. Roy. Soc. Vic., 1893, p. 18; Trans. Roy. Soc. S.A., 1893, p. 212; Krausé, First Prog. Rep. Geol. Surv. Vic., 1874, Section IV.

† Proc. Geol. Soc. Aust., vol. i., pt. i., p. 19, 1886.

‡ Proc. Roy. Soc. Vic., 1893, p. 16; and Prof. Tate, Trans. Roy. Soc. S. Aust., 1893, pp. 216, etc.

the Gellibrand River, are the the lowest members of the tertiary group occurring in Victoria, and are referable to the oligocene period, while the beds at Spring Creek are divided into upper, middle, and lower miocene. Selwyn states* that the older volcanic rock marks the close of the miocene period. These views are adopted by Mr. R. A. F. Murray in his work on the Geology of Victoria.

Professor Ralph Tate and Mr. J. Dennant in their paper on the Correlation of the Marine Tertiaries of Australia,† do not attempt any subdivision of the eocene beds, but state that by Professor McCoy the deposit at Mornington "is correctly placed at the base of the tertiary series,"‡ though, whether they intended to imply that it is the oldest of our eocene beds is not clear. Of the older basalt it is said that it may "ultimately prove to be cretaceous,"§ while more recently Professor Tate, as above indicated, refers it to pre-eocene age. Below this series of rocks we have, as shown by Selwyn,‖ at any rate one set of leaf-beds, namely those occurring below the older basalt. Whether these beds are still to be retained in the tertiary period, or are to be referred to cretaceous times is, as we have previously shown, still an open question.¶

SUMMARY.

Judging by the percentage of recent species of mollusca occurring in the various deposits, we should expect those of the Spring Creek type to underlie the clays of the Lower Muddy Creek type, and the detailed stratigraphical evidence that we have brought forward points in the same direction. We are then, on these grounds, justified in arranging the eocene rocks of Victoria, in so far as they have been critically examined, in the following order, beginning with the highest beds.

1. Clays of the Lower Muddy Creek Type.—Occurring at Muddy Creek, Mornington, Belmont, Curlewis, Lake

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* Exhibition Essays, 1866-67, p. 29.

† Trans. Roy. Soc. South Australia, 1893.

‡ *Loc. cit.*, p. 216.

§ *Loc. cit.*, p. 212.

‖ Exhibition Essays, p. 21.

¶ Aust. Ass. Adv. Science, Adelaide, 1893, p. 338.

Connewarre (Campbell's Point, etc.), Southern Moorabool Valley (Fyansford, etc.), Corio Bay, Altona Bay (bore), Newport (shaft), Gellibrand, Camperdown (Gnotuk), Murgheboluc, Shelford, Bairnsdale (Mitchell River).

2. Polyzoal Limestone of the Waurn Ponds Type.—Occurring at Waurn Ponds, Batesford, Maude, Curlewis, Flinders, ? Airey's Inlet, ? Muddy Creek.

3. Older Volcanic Rock.

4. Clays and Limestones of Spring Creek.—Maude and (?) North Belmont.

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Royal Society of Victoria.

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GEOLOGY OF THE LOWER MOORABOOL.

By T. S. HALL, M.A. (Demonstrator and Assistant Lecturer in Biology in the University of Melbourne;

and

G. B. PRITCHARD (Lecturer in Geology in the Working Men's College, Melbourne).

(Read 10th June, 1897).

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Art. V.—*Geology of the Lower Moorabool.*

By T. S. Hall, M.A.,

Demonstrator and Assistant Lecturer in Biology in the University of Melbourne;

and

G. B. Pritchard,

Lecturer in Geology in the Working Men's College, Melbourne.

(Plates I. and II.)

[Read 10th June, 1897.]

The valley of the Moorabool River from its confluence with the Barwon, at Fyansford, to a short distance above Maude, displays a series of sections extending over some twenty miles in length which clearly illustrate the diversified character and the relations of our marine tertiary beds and the deposits associated with them. We have previously described the series as shown at the southern end of the valley, and pointed out that the Miocene beds of the old survey really underlay their Oligocene (1). At a subsequent date we dealt with the tertiaries in the neighbourhood of Maude (2), and showed that the same sequence held, while the close relationship between the marine beds underlying the Older Volcanic rock and those of Spring Creek enabled us to indicate the sequence of the tertiaries generally. Since the publication of these papers we have examined the valley for some miles to the north of Maude, and also the undescribed and only partly mapped portion between Russell's Bridge (The Clyde) and the railway viaduct near the Moorabool Station. Our inspection of the beds shows that the general south-westerly dip, which we previously indicated as existing in the southern part of the valley, holds as far to the northward as Maude, near to which place the marine conditions give place to freshwater ones.

Beginning at the northern end of the area under consideration, we find that about half a mile above the confluence of Woolshed Gully, or about a mile and a half below the junction of

Coole Barghurk Creek, there is a thick mass of volcanic rock overlying the Ordovician. Its thickness we estimated at about 150 feet. The lower part of the igneous rock, as seen in several sections, is very much decomposed, while that near the surface is columnar and sound. It would appear from this that there is some difference in the age of the upper and lower parts.

On consideration we are inclined to think that the Newer Volcanic rock here rests on the Older Volcanic without the presence of any intervening beds, and it is not till we have gone some three miles to the southward, in the neighbourhood of the Maude Bridge, that we are able, owing to the occurrence of an intercalated marine limestone, to separate the two with certainty.

Under the volcanic rock occurs a deposit of sand and gravel, which can be traced down stream till it is clearly seen to pass in its upper part into the Lower Maude marine beds, the representatives, as we have previously stated, of the Lower Spring Creek series. To the northward these gravels, which are in places represented by quartzites, have been shown by Selwyn and the officers of his staff to underlie auriferous gravels, and where examined by them, to be not gold-bearing (5). From the data thus obtained, as well as from observations on some of the older gravels elsewhere, which were also non-auriferous, Selywn arrived at the conclusion that gold was not to be found in Miocene gravels. In the same report (5, p. 24) he says, "No beds whatever containing marine fauna are known in Victoria overlying alluvial or drift gold deposits." Since then, however, such beds have been found near Stawell under marine deposits of apparently Eocene age. Selywn's explanation of what he held to be the non-auriferous character of the Miocene gravels is that the age of the auriferous quartz reefs was Post-Miocene, the non-auriferous ones being of greater age. Now that we know of the existence of detrital auriferous deposits of greater age, another explanation of the absence of gold from the gravels north of Maude must be sought, and the true one appears obvious. The gold in our Ordovician is practically confined to beds of certain ages, and we thus find the north and south lines of auriferous country separated by barren belts. One of us has shown that such a barren belt is indicated at Castlemaine by the presence of graptolites belonging to what he has called the *Loganograptus*

zone (6, p. 76). Graptolites of a slightly higher horizon occur in Sutherland's Creek, and a few that may be of the same age at the localities shown on Quarter-sheet 19, S.W., in the Moorabool Valley. The reason, then, for the absence of gold in the gravels appears to be that they have been derived from a barren belt of Ordovician, and not that the character of the quartz veins depends on the age of their formation.

At the locality marked W.T.M.8. on the Quarter-sheet the summit of the Ordovician is about eighty feet above the level of the river, which flows through a rugged gorge. Half a mile below this the gravels pass up into marine beds.

These consist in the main of polyzoal limestones, and are strongly current bedded, containing quartz grains the size of a pea, as well as numerous flakes of slate. In places the limestone is crowded with vast quantities of the peculiar little echinoderm, *Fibularia*. These beds, which are a part of the "Lower Maude Series," are probably about the level of Lethbridge Station, which is 547 feet above sea level, and are the most northerly exposure of the marine beds. From here the surface of the Ordovician drops rapidly as we go south, and in about two miles it has disappeared beneath the level of the bottom of the valley. The Lower Maude series of marine beds, which have now almost entirely displaced the gravels, disappear in the same way a little further down stream, as shown on the Quarter-sheet. The section just above this is described in a previous paper (2); but it may be recalled to mind that the surface of the Older Volcanic rock is about 190 feet above the level of the stream, which has a fairly rapid fall. The limestone and sands overlying the Older Volcanic rock may be traced continuously for four miles to the southward, when we reach the quarry opposite the Clyde School (2, p. 183). Here the surface of the volcanic rock has dropped to about 40 feet above the level of the stream, in spite of the rapid fall of the latter. The Upper Maude limestone is now overlain by fossiliferous clays, into which it passes upwards, the fossils from the clays showing, as we have previously pointed out, the closest agreement with those of the clays associated with the Batesford limestone. About a mile and a half further down the stream we recently noted the most southerly outcrop of the Eocene basalt, namely in Section IV., Allotment B, Parish of Darriwill. The

following section is displayed on the left bank. From the water's edge up to 40 feet is a very vesicular and rubbly decomposed basalt. On this rests the Eocene rock. Fragments of polyzoal rock were found, as well as brown sandy limestone. Then occurs a stretch of level ground which runs back from the river to an escarpment of Newer Volcanic rock, which flanks the Maude table-land. There is no clear exposure of the Eocene rock in the section, but it is visible a quarter of a mile below under the Newer Volcanic rock, dropping rapidly to the southwards, as seen in the long cliff section. There is, as mentioned, no actual exposure of the Older Volcanic rock south of this, and judging by the soil and surface contour we think it comes to the river level near the house in Section IV., Allotment E (Calleray's). The slopes about here are composed of the marine series with the usual capping of Newer Volcanic rock. About half a mile south of Calleray's there is an exposure of Eocene in the river bed at the foot of a steep cliff. On the opposite (right) bank of the stream a long escarpment runs east and west, and the almost horizontal lines of stratification, as shown by the earthy limestone bands, are a marked feature in the landscape. From a road-cutting along the foot of this hill, about a couple of hundred yards above Moodie's homestead, we gathered a few fossils.

Brachiopoda.

Terebratula vitreoides, T. Woods.

Lamellibranchiata.

Ostrea sp.
Pecten murrayanus, Tate.
Lima linguliformis, Tate.
Leda vagans, Tate.
Nucula tenisoni, Pritchard.
Limopsis belcheri, Adams and Reeve.
Pectunculus laticostatus, Quoy and Gaimard.
Plagiarca cainozoica, Tate.
Corbula pyxidata, Tate.

Gastropoda.

Tenagodes occlusus, T. Woods.
Emarginula sp.

Scaphopoda.

Dentalium aratum, Tate.
Entalis mantelli, Zittel.
,, subfissura, Tate.

Half a mile below, a similar road-cutting near Baker's gave us another opportunity of seeing the nature of the beds clearly. The valley hereabouts is of less depth than almost anywhere else, being only about eighty feet deep. The marine beds are about sixty feet thick, and pass up from grey sandy marls into more sandy beds with bands of hard, ringing, concretionary limestone, and towards the top become more ferruginous. The face of the section is sparsely strewn with small quartz pebbles, but we could not find any bed from which they might be derived. The remaining twenty feet of the hill consists of the usual volcanic capping, the rock being a rather coarse dolerite, judging by hand specimens. Fossils were only obtained from the lower part of the section, are not very common, and are of Eocene age.

BAKER'S ROAD-CUTTING.

Foraminifera.
Zoantharia.

Flabellum victoriæ, Duncan.
Conosmilia anomala ?, Duncan.

Echinodermata (Cidaroid spines).
Polyzoa.
Lamellibranchiata.

Dimya dissimilis, Tate.
Pecten zitteli, Hutton.
Meleagrina crassicardia ?, Tate.
Barbatia celleporacea, Tate.
Leda vagans, Tate.
Trigonia tubulifera, Tate.
Crassatella communis, Tate.
Cardita polynema, Tate.
Cytherea eburnea, Tate.
Myochama trapezia, Pritchard.

Gastropoda.

Ranella prattii, T. Woods.
Genotia angustifrons, Tate.

Pleurotoma sp.
Thylacodes conohelix, T. Woods.

Scaphopoda.

Dentalium aratum, Tate.
Entalis subfissura, Tate.
,, mantelli, Zittel.

Pisces (otoliths).

About a mile to the south of this, on the road which runs south from Baker's Bridge, is a small cutting in yellow calcareous sandstone, with very hard bands of limestone. This proved a difficult bed to work for fossils, as they were very scarce, and when found consisted only of hollow casts. The nature of the rock, however, was such that the imprint of the ornament was beautifully sharp, and there was very little difficulty in recognising the greater number of the specimens as soon as they were exposed by the hammer.

GHERINGHAP.

Foraminifera.

Crustacea (crab chela).

Polyzoa.

Brachiopoda.

Terebratulina scoulari ?, Tate.

Lamellibranchiata.

Lima bassii, T. Woods.
Chione cainozoica, T. Woods.
Cardita delicatula, Tate.
Chama lamellifera, T. Woods.

Gastropoda.

Mitra ligata ?, Tate.
Scalaria sp.
Turritella tristira, Tate.
,, acricula, var., Tate.
,, platyspira, T. Woods.
Rissoa sp.

Scaphopoda.

Dentalium aratum, Tate.
Entalis mantelli, Zittel.

As a few hundred yards below this cutting there is a long outcrop of limestone marked on the Quarter-sheet, 24 N.E., the boundary of which we were now approaching, it was very necessary that clear evidence as to its age should be obtained. This strip of limestone is shown on the map as immediately underlying the Pliocene beds, which are mapped as very thick from here to the viaduct, and though the outcrop is clearly enough shown on the map, yet there was but one small exposure in an old disused quarry, the extent of the bed being indicated by the numerous scattered fragments of limestone at the foot of the escarpment. Owing to the unfortunate system of representing all limestones by a blue colour on the quarter-sheets, no hint of the age of the bed is given, and it is merely shown to underlie the Pliocene deposit. In the outcrop at the quarry we could find no identifiable fossils, a few fragmentary polyzoa and foraminifera being all that we saw. There can, however, be no doubt whatever that the outcrop is part of the same bed as is exposed in the road-cutting just mentioned, and it must consequently be referred to Eocene age.

To the north of this the river skirts the southern boundary of a small area of granite, as shown on the Quarter-sheet. South of the confluence of Sutherland's Creek, which skirts the granite area on its eastern border, a small exposure of limestone is mapped, and is represented as intercalated in Pliocene beds. At the locality indicated we found numerous boulders of white, hard, magnesian limestone strewn about near the foot of the slope, but it appeared not to be fossiliferous, and its original position is not clear. We found none *in situ*, and it may be merely a decomposition product from the overlying volcanic rock, and perhaps owes its present position to its having rolled down the face of the escarpment. To the south-west of this point, owing to the removal of the volcanic rock by denudation over about a square mile of country, a series of beds are brought to view which are mapped as "Older Pliocene." In their upper part they pass under the edges of the basalt plateau, and a couple of railway cuttings through small basaltic outliers show the relationship of the two sets of beds very clearly. The basalt cap, as shown in the cuttings, is very thin, nowhere exceeding twenty feet in thickness, and thins out to nothing at the two

ends of each of the cuttings. Under the basalt comes a deposit of ferruginous sandstone bands, sands and gravels, at times passing irregularly into white sands, with here and there a few nodules of hard quartzite just below the volcanic rock. The texture varies from exceedingly fine, well-rounded sands to light gravel, and a prolonged search for fossils in these cuttings showed, as is so often the case in rocks of this character, that organic remains are few and far between; in fact, all we found was the imprint of a single leaf, showing probably the fresh-water nature of the deposit. On the northern slopes towards the river, and at a lower level than these beds, the Quarter-sheet notes "Ironstone full of fossils." These fossiliferous beds are exposed in an old road-cutting leading down to the river, but fossils are more plentiful in the loose blocks which thickly strew the slopes below. The deposit is of especial interest, as the beds prove to be of Miocene age.

Moorabool Viaduct.

Miocene Fossils.

Lamellibranchiata.

Placunanomia ione, Gray.
Modiola sp.
Leda woodsi, Tate.
Leda sp.
Nucula tenisoni, Pritchard.
Trigonia acuticostata, McCoy.
Chione subroborata, Tate.
Cytherea submultistriata, Tate.
Mactra hamiltonensis ?, Tate.
Myadora corrugata, Tate.
„ brevis, Sowerby.
Corbula ephamilla, Tate.
Barnea tiara, Tate.

Gastropoda.

Phos tuberculatus, Tate.
Nassa sublirella, Tate.
„ crassigranosa, Tate.
Cancellaria wannonensis, Tate.

Pelicaria coronata, Tate.
Natica varians, Tate.
Turritella sp.
Lampania sp.
Bankivia sp.

The whole of the above twenty-two species are obtained in Miocene deposits elsewhere, whereas only five are recorded as ranging into the Eocene.

Of the above twenty-two species seventeen have been specifically named, including one doubtful identification; the remainder are as yet undescribed species.

The seventeen described species occur elsewhere as follows :—

Muddy Creek Miocene - -	17 (1 doubtful).
Jemmy's Point Miocene - -	17 ,,
Beaumaris Miocene - - -	13

The Quarter-sheet bears the same colour from the top of the hill down to the river flat, the whole series being referred to Older Pliocene. Towards the foot of the hill, however, the character of the beds changes, and, though we found no fossils, it is probable that the lower part of the beds is Eocene, as fossiliferous beds of this age occur less than half a mile lower down the stream and are in their upper part of similar lithological character.

The presence of marine Miocene beds here, where they are so clearly overlain by volcanic rock, is of importance when viewed in connection with a deposit recently described by Messrs. J. Dennant and J. F. Mulder at Shelford, about eighteen miles to the westward of the present locality (3). Finding the marine Miocene beds resting on basalt, and basalt also occurring further from the river, and at a higher level, these authors have assumed that the two basaltic outcrops belong to the same period and practically to the same flow. Arguing from these premises they state their view to be that the basalt forming this portion of the Western Plains is not younger than Miocene, and they ascribe the presence of the marine Miocene beds in that locality to a submergence after the gorge had been partly cut out by the stream. An examination of the section which they give, however, shows that a different interpretation may be placed on

their observations, namely, that there are really two basalts of distinct ages present and separated by marine beds. The fact that, at the Moorabool locality, the basalt overlies the Miocene beds is certainly strong presumptive evidence that the relative position to which Messrs. Etheridge and Murray referred the newest of the basalts of the Shelford district is the correct one, namely, that it is subsequent to the beds which the Survey termed Older Pliocene, and which are now generally called Miocene. Messrs. Dennant and Mulder state that, in the section in which they found the Miocene deposit, the base of the volcanic rock is hidden by the recent river alluvium. If then, as appears probable, there be two basalts at Shelford, the age of the lower one is still undetermined. It must be pre-Miocene, and from its close proximity to the Eocene basalt of Maude, it will quite possibly be found to be a part of the same flow.

The railway cutting on the left bank of the stream shows, under a thin basalt capping, beds of the same character as those described above on the right bank, and yielded no fossils. Eastwards from the Moorabool Railway Station the railway runs in the valley of Cowie's Creek, and several cuttings show the beds beneath the basalt capping, and they are also displayed in natural sections in the valley. Daintree and Wilkinson, who mapped the Quarter-sheet, 24 N.E., indicate two sets of beds as occurring, namely, "Older Pliocene" and "Miocene," or, as we consider them, Miocene and Eocene. Judged by the light of the section above described to the west of the viaduct, it is possible that this is correct, as the levels are about the same. The beds merely differ in the fact that these to the eastward are not highly ferruginous. They are sandy, sometimes calcareous, and in places in immediate contact with the overlying basalt are changed to quartzites. The dip is slight and is at first north-westerly, whereas further east, where the age is shown to be Eocene by the fossils, the dip is reversed, being to the south-east. These are only apparent dips, as shown in the railway cutting. About four miles to the northward a small patch of Miocene (? Eocene) is mapped (this outcrop is uncoloured in some copies of the Quarter-sheet, but is coloured Miocene in others), and an anticline with a north-east strike is shown. The axis of the anticline would run, if produced in a straight line, near to this locality.

The evidence, then, as to whether we have here an anticline in Eocene strata merely, or an unconformable junction between easterly dipping Eocene and westerly dipping Miocene is fairly evenly balanced, and we leave the question open. At the locality marked as fossiliferous on the Quarter-sheet (Section 104) we found fossils in the railway cutting and also close to the creek bed which showed the Eocene age of the deposit. The upper beds yield very few forms, but those at the lower level are fairly rich, though the fossils are very much decomposed.

RAILWAY-CUTTING.

Foraminifera.
Cidaroid spines.
Crustacea (crab carapace).
Polyzoa.
Brachiopoda.
Waldheimia insolita ?, Tate.
Terebratulina scoulari, Tate.
Lamellibranchiata.
Ostrea sp.
Pecten sp.
Limatula jeffreysiana ?, Tate.
Spondylus pseudoradula, McCoy.
Dimya dissimilis, Tate.

COWIE'S CREEK.

Brachiopoda.
Terebratulina scoulari, Tate.
Lamellibranchiata.
Pecten zitteli, Hutton.
Leda vagans, Tate.
,, apiculata, Tate.
,, huttoni, T. Woods.
Limopsis belcheri, Adams and Reeve.
Plagiarca cainozoica, Tate.
Cardita polynema, Tate.
,, delicatula, Tate.
Diplodonta subquadrata, Tate.
Cytherea eburnea, Tate.

Pholadomya australica, Tate.
Cuspidaria subrostrata, Tate.

Gastropoda.

Cypræa leptorhyncha, McCoy.
Cassidaria gradata, Tate.
Natica hamiltonensis, T. Woods.
Turritella sp.
Tenagodes sp.
Cerithium apheles, T. Woods.
Tinostoma parvula, T. Woods.
Emarginula sp.
Cylichna sp.

Scaphopoda.

Dentalium aratum, Tate.
Entalis mantelli, Zittel.
,, subfissura, Tate.

With the exeception of the section noticed by us in a previous paper (1), there does not appear to be any fossiliferous exposure of Eocene rocks between the viaduct and the limestones below Batesford. In the same paper we described the nature of the beds displayed in the river sections between Hope's Mill-dam and Fyansford, and subsequently again referred to the section displayed at M'Cann's Filter Quarries (2, p. 193), and gave a list of fossils from the clays of the section (4, p. 161).

The question of the difference of level of the lava on the two sides of the Moorabool, between Batesford and Fyansford, we alluded to in a previous paper (1). It seems probable that the lava to the west, occupying the lower level, is younger than that capping Orphanage Hill, the latter being a southerly extension of that capping the Miocene beds near the viaduct. This suggestion would, of course, imply great denudation over a considerable area after the effusion of the Orphanage Hill lava. From a careful examination of the district we do not think that it can be due to faulting, although faulted marine tertiaries occur at no great distance, namely at Waurn Ponds and at Curlewis. At the former place the limestone at M'Cann's old quarry is cut off to the southward by a vertical fault, the amount and direction of the displacement not being known, and the quarry is abandoned, while the slight series of step faults at Curlewis we have described elsewhere.

SUMMARY.

The long series of sections displayed in the valley of the Moorabool shows very clearly the sequence of our Eocene rocks. The general dip is in the direction of the stream, and at a more rapid rate than the fall of the valley, so that the beds disappear in regular order as we go southwards. The Upper Marine Series near Maude, classed as Upper Miocene by the Survey, is seen to pass beneath clays which are the near representatives of, if not absolutely identical with, those of Orphanage Hill, Fyansford, which have been referred by the Survey to the Oligocene. and by us to the Eocene. These beds extend in the valley from near the Maude bridge, with perhaps a short break near the junction of Sutherland's Creek, to the Barwon. Near the viaduct they are overlain by marine and freshwater Miocene beds, which are in turn capped by the lava flow of the plains.

Beneath the Upper Maude beds is seen the Older Volcanic, extending from near the confluence of the Coole Barghurk Creek for about ten miles down stream, when it disappears beneath river level. Under the Older Volcanic sheet, and between it and the Ordovician, is a series of beds which to the northward is of freshwater origin and contains plant remains—the "Miocene gravels" of Selwyn. At about two miles above Maude they contain a marine fauna in their upper portion, and they dip below river level some three miles below this point. This fauna we have previously correlated with that of Spring Creek.

A tongue of the Anakie granite, as shown by numerous outcrops, extends down Sutherland's Creek, through the Dog Rocks, and reaches as far to the southward as the north-western border of the Barrabool Hills. At the Dog Rocks and at the Barrabool Hills gabbro is associated with it. The relations of the two rocks are being, we understand, worked out by Mr. E. G. Hogg. Here, as elsewhere in Victoria, the granite is probably Post-Silurian, and intrudes the graptolite-bearing Ordovician, which is extensively exposed in the northern parts of the area treated of.

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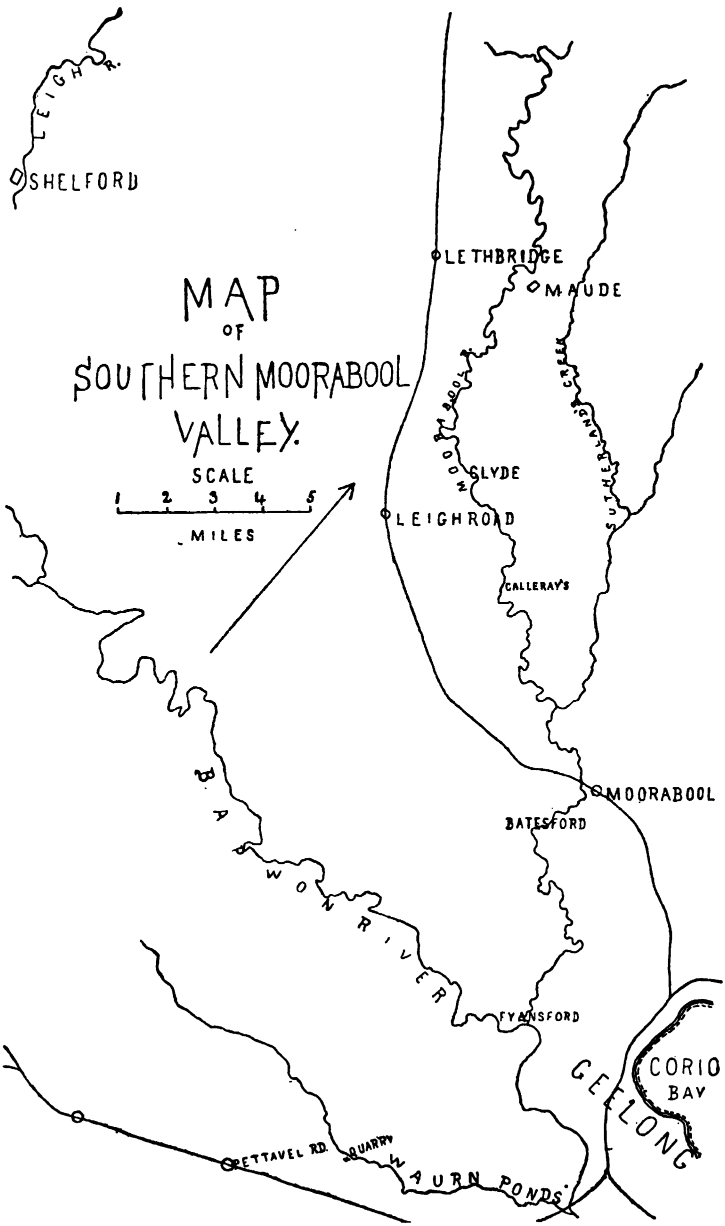
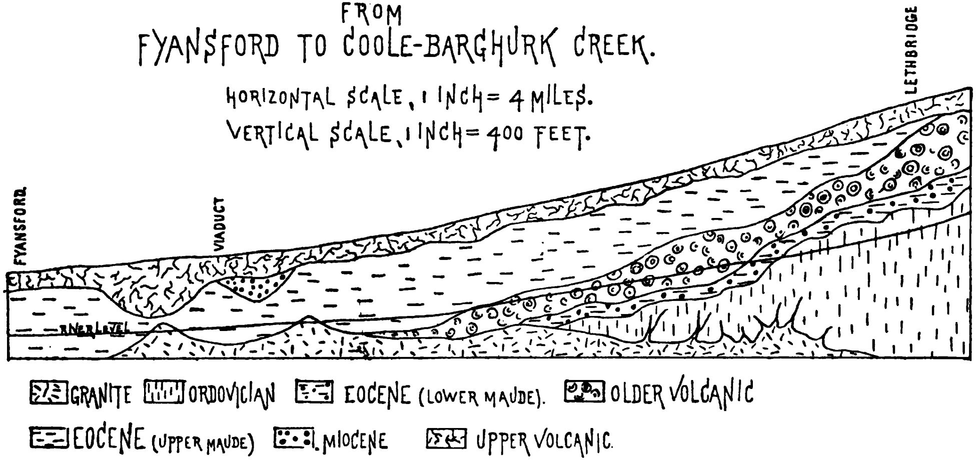
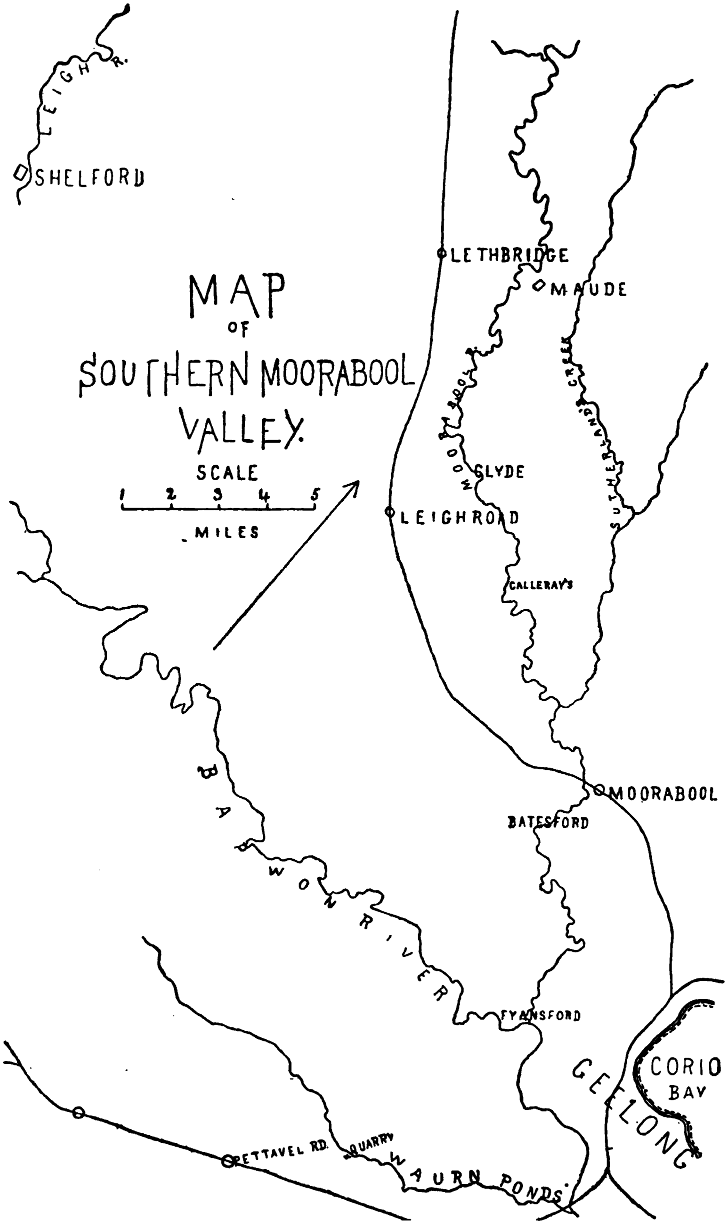


MAP OF SOUTHERN MOORABOOL VALLEY.
SCALE
1 2 3 4 5
MILES
LEIGH R.
SHELFORD
LETHBRIDGE
MAUDE
MOORABOOL R.
SUTHERLAND'S CREEK
CLYDE
LEIGH ROAD
CALLERAY'S
MOORABOOL
BATESFORD
BARWON RIVER
FYANSFORD
GEELONG
CORIO BAY
PETTAVEL RD.
QUARRY
WAURN PONDS

SECTION
FROM
FYANSFORD TO COOLE-BARGHURK CREEK.

HORIZONTAL SCALE, 1 INCH = 4 MILES.
VERTICAL SCALE, 1 INCH = 400 FEET.




MAP
OF
SOUTHERN MOORABOOL
VALLEY.
SCALE
1 2 3 4 5
MILES
LEIGH R.
SHELFORD
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MAUDE
MOORABOOL R.
SUTHERLANDS CREEK
CLYDE
LEIGH ROAD
CALLERAY'S
MOORABOOL
BATESFORD
BARWON RIVER
FYANSFORD
GEELONG
CORIO
BAY
PETTAVEL RD.
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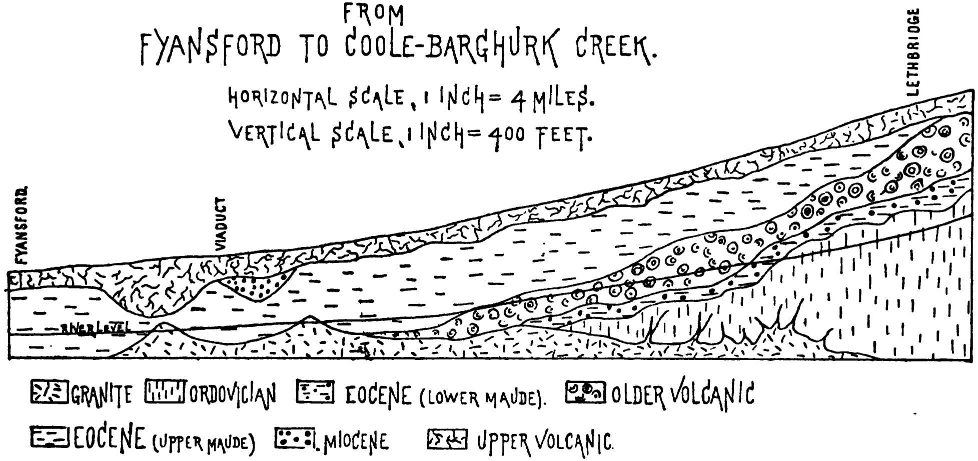
SECTION FROM FYANSFORD TO COOLE-BARGHURK CREEK.

HORIZONTAL SCALE, 1 INCH = 4 MILES.
VERTICAL SCALE, 1 INCH = 400 FEET.



Royal Society of Victoria.

THE TERTIARY DEPOSITS OF THE AIRE AND CAPE OTWAY.

By T. S. HALL, M.A., and G. B. PRITCHARD.

(*Read 13th April, 1899*).

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ART. IV.—*The Tertiary Deposits of the Aire and Cape Otway.*

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AND

G. B. PRITCHARD,

Lecturer in Geology in the Working Men's College.

(With Plate VI.)

[Read 13th April, 1899.]

PREVIOUS NOTICES.

In 1864, during the absence from the colony of Mr. Selwyn who was visiting England on leave, the duties of Director of the Geological Survey devolved on Mr. Aplin, the senior field geologist, and yielding to the public demand for more rapid surveys than were being executed in the careful quarter-sheet work inaugurated by his chief, he instructed Messrs. Daintree and Wilkinson, who had just completed their work in the neighbourhood of Ballan and Bacchus Marsh, to examine and report on the Cape Otway District. The only visit hitherto paid by any of the staff to the district was one made by Mr. Selwyn in 1858, when he examined the coast-line as far as Apollo Bay (1, p. 11). Before arrangments could be completed Mr. Daintree finally quitted Victoria for Queensland, and Mr. Wilkinson was placed in charge of the party, with Mr. R. A. F. Murray as assistant (2, p. 11). Wilkinson sent in a preliminary report (3 and 4) and then a more detailed one (5) accompanied by a section and map (6). Duncan reprinted (7) that part of the detailed report which dealt with what were termed the Miocene beds by Wilkinson, reproducing a part of the section but omitting some of the explanations and thus misleading Messrs. Tate and Dennant who did not consult Wilkinson's original reports (12, p. 115). In 1873 Mr. F. M. Krausé partially surveyed the country to the east of Cape Otway but does not seem to have gone further west

than Apollo Bay (9). He published a sketch map (10) in which he apparently relied on Wilkinson's survey for the details of the country about the Aire River. By neglecting a thickness in places of about 200ft. of dune rock, the æolian origin and extent of which are clearly indicated by Wilkinson, he has shown a large area occupied by the miocene of the survey. As regards the courses of the streams through the Aire Marsh Wilkinson's map, it may be mentioned, though the oldest, is the most correct; Krausé's being singularly inaccurate both here and elsewhere, a fact doubtless due to the enforced rapidity of the survey.

Mr. R. A. F. Murray, who had accompanied Wilkinson on his survey, gives in 1887 (11) a few further particulars, the outcome apparently of some unofficial visit to the Ford.

In 1895 Messrs. Tate and Dennant visited the Otway section (12 and 13), but though they report that they carefully examined the coast-line they were unable to find any of the outcrop west of the Aire indicated by Wilkinson, with the exception of the one in front of Mr. Robinson's house. As will be seen in the sequel all the latter author's localities, with perhaps one exception, are visible now just as he described them over thirty years ago.

In January, 1897, the present authors spent about a fortnight at the Aire, and found that Wilkinson's report and map were excellent guides to the locality which we purpose describing in some detail.

The mesozoic sandstones which occupy such a large area of the Otway district, are interrupted between Cape Flinders and Castle Cove by newer rocks which descend to the shore and extend inland for several miles, occupying a basin in the older series. In these newer rocks Wilkinson recognised three distinct members:—A set of marine and freshwater beds which he regarded as miocene and which in common with Messrs. Tate and Dennant we refer to as eocene; another, consisting of ferruginous conglomerates and sandstones flanking the slopes of the mesozoic rocks, capping the lower hills and which be called pliocene tertiary (5, p. 25); and lastly, the dune rock.

To the S.E. of the mouth of the Aire the coast is occupied by sand dunes with a few patches of dune rock on the beach and near the river mouth itself. In places on the front of the cliffs

the loose sand has been removed and it is seen that the greater part of the high land is formed of the consolidated rock. The dune rock occupies a large area on the Otway side of the river and the park like country is in strong contrast to the heavily timbered mesozoics further inland. Krausé has coloured the sea front as mesozoic but no trace of rocks of this age are seen between Cape Flinders and Castle Cove. On the west of the river the high sea cliffs are formed of dune rock weathered into fantastic crags and precipices, bare in some places and in others clothed with low and almost impenetrable scrub. The cliffs rise to a height of about 200ft. The eocene rocks which underlie the dune rock near Castle Cove nowhere rise to more than about 30ft. above sea level, while the high land between the sea and the Aire Marsh is almost entirely composed of dune rock of at least 200ft. in thickness. The whole of this cover is neglected by Krausé who maps it as miocene (of the survey).

Eocene.

It will be convenient to consider separately the localities which we examined.

Spud Point.

This point is formed by a small outcrop of eocene limestone which rises some 30ft. above the Aire Marsh and forms a tongue shaped area a few acres in extent. On its northern border the mesozoic rocks rise as a steep escarpment to a height of over 200ft. The outcrop is some 300 yards from Mr. Robinson's house and is the one alluded to by Messrs. Tate and Dennant. The rock consists of a yellow polyzoal limestone, the fossil fragments being much comminuted and mixed with quartz grit and pebbles up to a cubic inch in size, most of these being well rounded. The limestone is in places very hard and contains rounded concretionary masses of glazed limonite which are sometimes a couple of inches in diameter and from their resemblance to potatoes probably give the point its local name. In places a glazed deposit of limonite spreads over the joint faces in broad patches. Identifiable fossils are scarce, the rock being principally composed of worn polyzoa and stems of *Isis*. The stratification is not very clear but is apparently horizontal.

The following fossils were obtained :—

Corals.

Isis, sp.

Echinoidea.

Lovenia forbesi, Woods and Duncan.
Cyclaster archeri, T. Woods.
Eupatagus rotundus, ? Laube.
Scutellina patella, Tate.
Cidaroid spines.

Polyzoa. Abundant.

Brachiopoda.

Rhynchonella squamosa, Hutton.
Magellania grandis, T. Woods.
" furcata, Tate.
" insolita, Tate.
Magasella compta, G. B. Sowerby.

Lamellibranchiata.

Ostraea, sp.
Placunanomia sella, Tate.
Hinnites corioensis, McCoy.
Pecten murrayanus, Tate.
Pecten foulcheri, T. Woods.
" sp., *aff.*, peroni.
Lima bassii, T. Woods.
Spondylus gaederopoides, McCoy.
Pectunculus laticostatus, Q. and G.
Cardium sp., *aff.*, C. hemimeris.

Gastropoda

Cypraea, sp. (casts).
Pleurotoma, sp.
Cassidaria wilsoni, Tate.
Thylacodes, sp.
Voluta, sp. (cast.)

The cast of Voluta is in the possession of Mr. Robinson of the Aire Station and is related to V. stephensi, Johnston. This is apparently the specimen referred to by Messrs. Tate and Dennant as V. mortoni, and if so is an identification which we cannot accept.

Fishing Point.

For about a mile inland from the mouth of the Aire the country is occupied by sand dunes. For a couple of miles further the eocene rocks crop out on the low hills forming the eastern borders of the marsh. Possibly they extend a little further but the dense nature of the vegetation together with the character of the rocks as we went inland induced us to go no further than where Wilkinson had indicated the last outcrop. As far north as Fishing Point the rocks consist of clay beds intercalated with fine grained yellow limestone, gritty polyzoal rock and ferruginous grit, the grains reaching the size of a pea. Small landslips are common on the face of the low hills, and on the fresh ones we secured a fair number of fossils. The stratification appears to be quite horizontal, while with regard to the fossils it is interesting to note that Murray (11, p. 101) referred the beds to the oligocene of the survey, correlating them with those of the Gellibrand, Mornington and the Moorabool Valley, and thus indicating the close relationship which undoubtedly exists between them.

The following fossils were obtained :—

Foraminifera. Several forms.

Corals.

Placotrochus deltoideus, Duncan.
,, elongatus, Duncan.
Flabellum victoriae, Duncan.
Notocyathus australis, Duncan.
,, excisus, Duncan.
,, viola, Duncan.
Conosmilia anomala, Duncan.

Echinoidea.

Cidaroid plates and spines.

Annelida.

Calcareous worm tubes.

Crustacea.

Crab chelae.
? Balanus, sp.

Polyzoa. Common.

Brachiopoda.

Magellania divaricata, Tate.

Magasella compta, G. B. Sow.
Terebratulina scoulari, Tate
 „ catinuliformis, Tate.
Rhynchonella squamosa, Hutton.

Lamellibranchiata.

Dimya dissimilis, Tate.
Placunanomia ione, Gray.
 „ sella, Tate.
Pecten yahlensis, T. Woods.
 „ murrayanus, Tate.
 „ foulcheri, T. Woods.
 „ sturtianus, Tate.
 „ polymorphoides, Zittel.
 „ zitteli, Hutton.
Lima bassi, T. Woods.
Spondylus pseudoradula, McCoy.
Nucula atkinsoni, Johnston.
Nuculana apiculata, Tate.
Limopsis belcheri, Adams and Reeve.
Pectunculus cainozoicus, T. Woods.
 „ laticostatus, Q. and G.
Barbatia crustata, Tate.
Plagiarca cainozoica, Tate.
Cucullaea corioensis, McCoy.
Trigonia subundulata, Jenkins.
 „ tubulifera, Tate.
Crassatella dennanti, Tate.
 „ communis, Tate.
Cardita polynema, Tate.
 „ delicatula, Tate.
Diplodonta subquadrata, Tate.
Chama lamellifera, T. Woods.
Chione cainozoica, T. Woods.
Meretrix eburnea, Tate.
Myadora tenuilirata, Tate.
Corbula ephamilla, Tate.

Gastropoda.

Typhis evaricosus, Tate.
 „ acanthopterus, Tate.

Murex velificus, Tate.
,, eyrei, T. Woods.
,, trochispira, Tate.
,, amblyceras, Tate.
,, asteriscus, Tate.
,, lophoessus, Tate.
Muricidea polyphyllus, Tate.
Argobuccinum maccoyi, Pritchard.
Lotorium woodsi, Tate.
,, annectans, Tate.
,, tortirostris, Tate.
,, cyphus, Tate.
,, acanthostephes, Tate.
,, craspedotus, Tate.
,, foliaceus, Tate.
,, senticosus, Tate.
Fasciolaria decipiens, Tate.
Sipho crebregranosus, Tate.
Siphonalia longirostris, Tate.
Euthria ino, Tate.
Zemira præcursoria, Tate.
Nassa tatei, T. Woods.
Voluta hannafordi, McCoy.
,, maccoyi, T. Woods.
,, halli, Pritchard.
,, conoidea, Tate, var.
,, antiscalaris, McCoy.
Mitra leptalea, Tate.
,, paucicostata, Tate.
,, semilaevis, Tate.
Marginella propinqua, Tate.
,, winteri, Tate.
,, wentworthi, Tate.
,, micula, Tate.
,, cassidiformis, Tate ?
Ancillaria pseudaustralis, Tate.
,, semilævis, T. Woods.
Columbella funiculatus, T. Woods.
,, cainozoica, T. Woods ?

Cancellaria calvulata, Tate.
 „ gradata, Tate.
 „ exaltata, Tate.
 „ etheridgei, Johnston.
 „ varicifera, T. Woods.
Bathytoma rhomboidalis, T. Woods.
Teleochilus gracillimum, T. Woods.
Pleurotoma murndaliana, T. Woods.
 „ trilirata, Harris.
 „ optata, Harris.
 „ clarae, T. Woods.
Drillia trevori, T. Woods.
Mangelia obsoleta, Harris (?)
Clathurella obdita, Harris.
 „ bidens, T. Woods
Conus heterospira, Tate.
 „ hamiltonensis, Tate.
Cypraea leptorhyncha, McCoy.
 „ contusa, McCoy.
 „ brachypyga, Tate.
Trivia avellanoides, McCoy.
Semicassis sufflata, T. Woods.
Cassis exigua, T. Woods.
Natica hamiltonensis, T. Woods.
 „ polita, T. Woods.
 „ sub-noae, Tate.
 „ subinfundibulum, Tate.
 „ substolida, Tate.
Crepidula unguiformis, Lamarck.
Solarium wannonensis, T. Woods ?
Turritella platyspira, T. Woods.
 „ acricula, T. Tate, var.
Tenagodes occlusus, T. Woods.
Eulima danae, T. Woods.
Niso psila, T. Woods.
Mathilda transenna, T. Woods.
Cerithium apheles, T. Woods.
Newtoniella cribarioides, T. Woods.
Liotia roblini, Johnston.

Tinostoma parvula, T. Woods?
Bullinella exigua, T. Woods.
,, paucilineata, Cossman.
Subemarginula occlusa, Tate.
Styliola rangiana, Tate.

Scaphopoda.

Dentalium mantelli, Zittel.
,, subfissura, Tate.
,, aratum, Tate.

Corals - - - - - -	7
Echinoidea - - - -	1
Annelida - - - -	1
Brachiopoda - - - -	5
Crustacea - - - -	2
Lamellibranchiata - - -	31
Gastropoda - - - -	85
Scaphopoda - - - -	3
	135

The Calder Limestones.

On the northern side of a small creek which enters the marsh about three quarters of a mile above Fishing Point the strata become more calcareous and the rocks in places have a lithological resemblance to the polyzoal limestones of Waurn Ponds. In other places they are more earthy and are more than usually devoid of molluscan remains. We gathered a few fossils, most of which were obtained from a low wall of rock about fifteen feet high on the northern slope of the spur.

As at Fishing Point the strata are nearly horizontal and thus present a marked difference from the highly inclined beds of the coast sections near at hand, while the distinction is as clearly marked by the palaeontological evidence.

The following is a list of fossils found :—

Corals.

Isis, sp.

Echinoidea.

Eupatagus rotundus, Laube.
Psammechinus woodsi, Laube.
Scutellina patella, Tate.

Brachiopoda.

Magellania grandis, T. Woods.
Terebratulina catinuliformis, Tate.
Magasella compta, G. B. Sowerby.
Rhynchonella squamosa, Hutton.

Lamellibranchiata.

Placunanomia sella, Tate.
Dimya dissimilis, Tate.
Pecten yahlensis *var* semilaevis, McCoy.
,, murrayanus, Tate.
,, foulcheri, T. Woods.

The Aire Coastal Sections.

For a little more than half a mile westward from the river mouth nothing but dune rock is seen on the beach which is impracticable except at low tide, and even then the passage is rough, as the enormous blocks of dune rock, weathered into sharp points, lie piled in the wildest confusion. Then a small sandy bay is reached, to which we afterwards found access could be easily gained from the downs above. The best way to reach it is to follow a fence which runs to the edge of the cliffs from the stockyard which is situated on the landward slope. About two hundred yards west of the fence a cattle track goes down to the beach. On the eastern side of the bay among the tumbled blocks of dune rock is a small exposure of black clays. This lies on the shoreward side of a prominent pinnacle, about thirty feet high, which is probably what is marked as the Sentinel Rock on Wilkinson's map. The strata consist of black and grey sandy clays with pyrites, gypsum and what appeared to be copiapite.

There is in places a good deal of carbonaceous matter, and the well-rounded sand-grains are at times as large as a pea. There is about twenty-five feet in vertical thickness exposed, and the outcrop is about a chain in length. We could not find any beds showing beneath these clays, and as the dip is E. 35° N. at 12°, the reverse of Wilkinson's observations, it is evident that it is not

the outcrop which he noted and which we were unable to discover. (5, p. 23). As that author points out the physical appearances of the deposit are the same as those of the Point Addis clays on which the polyzoal limestone rests and he referred both to the same horizon. A few chains S.E. of this point we found a loose block of Eocene limestone containing an umbilicated *Nautilus* about six inches in diameter and *Trigonia subundulata*, but could find no outcrop.

Wilkinson's No. 4 Locality.

About three quarters of a mile west of the outcrop of lignitic clays polyzoal limestone crops out extensively on the beach and is Wilkinson's No. 4 locality. The beds dip south-easterly, the strike being at right angles to the coast-line, and as hard and soft beds alternate fairly regularly the platform of rock which is exposed by the falling tide is furrowed like an old ploughed field and presents a striking dissimilarity from the dune rock which occurs elsewhere in the neighbourhood. A belt of sandy beach, fifteen yards wide, intervenes between this platform and the deposit at the foot of the cliffs where the tabular masses rise as high as one's head and are crowded with fragmentary fossils. To the N.W. the limestone overlies argillaceous rocks, of which there is only a small outcrop rising not far above extreme high water mark. The section from above downwards is :—

54ft.	0in.	of polyzoal limestone with softer bands; full of quartz, grit and rounded pebbles.
	6in.	concretionary limonite with well rounded quartz pebbles.
2ft.	0in.	clay and limestone.
	6in.	limestone.
1ft.	6in.	grey clay.
	6in.	gritty limestone.
3ft.	0in.	grey clay.
1ft.	0in.	yellow limestone with polyzoa.
	6in.	clay.
	9in.	yellowish limestone.
	6in.	grey clay.
1ft.	0in.	concretionary limestone with brachiopods and echinoids.

	3ft. 6in.	grey clay with *Turritellas.*
	1ft. 0in.	fawn coloured limestone.
	4ft. 0in.	grey sandy clay, rich in fossils.
	1ft. 0in.	grey clay with abundant polyzoa.
	2ft. 0in.	fawn coloured hard limestone with small pockets of clay, with polyzoa, brachiopods and corals.
	15ft. 0in.	dark grey clay, cutting like new cheese and becoming very hard on drying. Fossils scarce, principal ones Turritella aldingæ scaphopods and pteropods with large unbroken pieces of delicately branched polyzoa.
Total	92ft. 3in.	

The dip of the beds is S. 25° E. and varies from 18° to 20°.

The following fossils were obtained :—

Corals.

Graphularia senescens, Tate.
Conosmilia striata, Duncan.
Placotrochus elongatus, Duncan.
Notocyathus viola, Duncan and Woods.
Flabellum distinctum, Edw. and H.
Balanophyllia campanulata, Duncan.
  „ selwyni, Duncan.
  „ cylindrica, Michelotti.
Cycloseris tenuis, Duncan.

Echinoidea.

Cidaris (Leiocidaris) australiae, Duncan.

Brachiopoda.

Terebratula vitreoides, T. Woods.
Magellania insolita, Tate.
Terebratulina triangularis, Tate.

Lamellibranchiata.

Pectunculus cainozoicus, T. Woods.
  „ laticostatus, Q. and G.
Myadora tenuilirata, Tate.
  „ lamellata, Tate.
Cardita polynema, Tate.
  „ delicatula, Tate.

Cardium victoriae, Tate.
Pinna cordata, Pritchard ?
Fossularca equidens, Tate.
Trigonia subundulata, Jenkins.
Limopsis insolita, G. B. Sow.
Dimya sigillata, Tate.
Meretrix tenuis, Tate.
Tellina masoni, Tate.
Corbula pixidata, Tate.

Gastropoda.

Natica wintlei, Tate.
Voluta anticingulata, McCoy.
Turritella aldingae, Tate.
„ conspicabilis, Tate.
Fusus acanthostephes, Tate.
Lotorium tortirostris, Tate
Marginella wentworthi, T. Woods.
Borsonia otwayensis, Tate.
Scalaria pleiophylla, Tate.
Mesalia stylacris, Tate ?
Dentalium mantelli, Zittel.
„ subfissura, Tate.

The whole of these fossils occur in the "4ft. of grey sandy clay, rich in fossils" mentioned above in the description of the section.

For 250 yards along the beach to the north-west the clay beds are covered by loose sand and dune rock when the next outcrop of eocene rocks is met with.

WILKINSON'S NO. 3 LOCALITY.

The rock, a gritty polyzoal limestone, shows as a small cliff 20ft. high, from which a platform runs seawards with westerly facing scarp which extends breast high above the sand and which has to be climbed over when going along the coast. The dip is N. 40° W. at 12°.

From here to Castle Cove the beach is formed of huge blocks of dune rock and progress is slow and painful, as the rock weathers into very hard jagged points.

The following fossils were found at this place (No. 3) :—

Corals.

Graphularia senescens, Tate.

Echinoidea.

Scutellina patella, Tate.
Lovenia forbesi, Woods and Duncan.
Echinobrissus vincentianus, Tate.
Cassidulus australiae, Duncan (Echinobrissus).

Brachiopoda.

Magellania grandis, T. Woods.
,, garibaldiana, Davidson.
Magasella compta, G. B. Sowerby.
Terebratulina catinuliformis, Tate.
Crania quadrangularis, Tate.
Rhynchonella squamosa, Hutton.

Lamellibranchiata.

Pecten foulcheri, T. Woods.
,, murrayanus, Tate.
,, yahlensis *var* semilaevis, McCoy.
,, hochstetteri, Zittel.
,, peroni, Tate.
Hinnites corioensis, McCoy.
Limatula jeffreysiana, Tate.
Spondylus pseudoradula, McCoy.
,, gæderopoides, McCoy.

Mammalia.

Squalodon wilkinsoni, McCoy.

NOTE.—Wilkinson, who found the specimen, says this is the locality where the type of Squalodon wilkinsoni was found. Sir Frederick McCoy quotes it as from Castle Cove, which of course is quite close at hand.

CASTLE COVE (WILKINSON'S NO. 5).

The fossiliferous rocks here form a cliff 30ft. high scantily overgrown with small shrubs, and extend for about one and a half chains along the beach. The dip is E. 38° S. and varies in amount from 35° to 40°. The lowermost beds consist of grey clays in thin irregular beds intercalated with hard detrital limestone consisting of comminuted fragments of polyzoa and shells. The limestones become more persistent as we pass up and are here full of brachiopods and joints of Pentacrinus, becoming more ferruginous at a higher level and containing numerous small

quartz pebbles. Overlying the limestones, and apparently conformable to them, is a series of unfossiliferous grey sands with plentiful spangles of white mica up to a quarter of an inch in diameter. These pass up into hard ferruginous grits which dip to sea level on the east and cap the mesozoic rocks on the west. Though apparently quite conformable to the high dipping Eocene it is possible that these grits are much younger than they. If they are Eocene then much of the inland gravel and grit capping of the mesozoic with which they seem continuous will be far older than Wilkinson considered it. The actual junction of the fossiliferous beds with the mesozoic is hidden by drifting sand, and over this the path to the beach passes.

An examination of the list of fossils from this locality shows that a number hitherto known only from Aldinga occur, while at the same time the relationship to the Spring Creek lower beds is pronounced; in fact the Castle Cove section emphasises the close faunal resemblance between Spring Creek and Aldinga.

The fossils occurring are as follows:—

Corals.

Flabellum distinctum, Edw. and Haime.

Echinoidea.

Leiocidaris australis, Duncan.
Cassidulus australiæ, Duncan. [(Echinobrissus) Type locality.]
Eupatagus coranguinum, Tate.
Hemiaster planedeclivis, Gregory.

Crinoidea.

Pentacrinus stellatus, Hutton.

Brachiopoda.

Terebratulina triangularis, Tate.
Magellania pectoralis, Tate.
,, insolita, Tate.
,, tateana, T. Woods.
Crania quadrangularis, Tate.
Terebratula aldingæ, Tate.

Lamellibranchiata.

Gryphaea tarda, Hutton.
Pecten peroni, Tate.
,, yahlensis, T. Woods.
Chione cainozoica, T. Woods.

Chione halli, Pritchard.
Cardita polynema, Tate.
Myadora lamellata, Tate.

Cape Otway.

A list of fossils from this locality has been published and discussed by Messrs. Tate and Dennant, and the beach exposure was briefly described by them (12 and 13). Inland from the coast about half a square mile of swampy land occurs surrounded by high sand dunes. The streams draining from these swamps run over the sea front of the beds which consist entirely of slipped material which has in places flowed out like thick porridge and in this are mingled dune rock, recent shells blown up from the beach and fossils. The only eocene rock we could find *in situ* was about 200 yards from the beach where a small runnel had cut down through the peaty soil to yellow clay with a few fossils in it; but no sign of stratification could be seen owing to the small extent of the exposure.

On the coast-line the mesozoic rocks rise sharply to the south-east and above the level of the eocenes and occupy the coast-line as far as Point Castries, some six miles north-east of Lorne.

An examination of the details given above of the beds exposed at Wilkinson's No. 4 locality will show that during the deposition of the series there, a gradual shallowing of the water took place. The lowermost beds are fine grained and compact and almost the only fossils are beautifully perfect pieces of polyzoa, the long delicate branches of which are unbroken, thus pointing to comparatively undisturbed depths. As we pass up through the series the rocks become coarser till we reach the uppermost beds exposed, the polyzoal limestone, which is full of quartz grit and rounded pebbles. Thus we see that a polyzoal limestone may be deposited in quite shallow water close to land and we may then consider what evidence there is that the limestones of our tertiary beds represent deep water deposits and that the clays represent strata laid down at lesser depths, a conclusion arrived at by Duncan and adopted by many subsequent writers. Our polyzoal limestones are composed of fragments of all sorts and

mostly broken into small pieces. Foraminifera are frequently common, and occasionally constitute the bulk of the rock, as at Batesford and the Grange Burn where the large Orbitoides and Nummulites lie at all angles. In other places fragments of polyzoa form the mass of the beds, with scattered and frequently worn spines of echini, joints of isis, brachiopods and the like. Echinoids, when unbroken, are as often upside down as not and in fact as far as the condition of the organic remains is concerned it points to deposition in shallow water where considerable movement has taken place. But besides this in almost every place where a careful description of the rock has been given we find undoubted traces of coarse detrital matter derived from the land. At Waurn Ponds coarse grits and sandy clays are intercalated with the limestone. Fragments of felspar, quartz and mica are common, derived evidently from the granite area which is partly exposed a few miles to the north-west, and in places the rock is well current-bedded, a feature clearly displayed in many of the blocks of this widely used building stone. At Batesford the polyzoal limestone passes down in places into current-bedded orbitoides limestone and this in its lower part rests on granite and contains numerous granite pebbles. The Lower Maude limestones, which are polyzoal in places, pass down into sands and conglomerates, while the similar limestones of the upper beds contain rounded boulders and pebbles of the underlying volcanic rock. Exactly the same features are shown in the cliffs at Airey's Inlet where an eroded volcanic rock underlies the polyzoal limestone which fills deep pockets and chasms in its surface. On the Grange Burn, near Hamilton, the limestone again is plastered down into the crevices and clefts of the igneous rock. The same thing again occurs at Flinders, Curlewis and Keilor, in fact in almost every place where the underlying beds are exposed we find that polyzoal limestone was the first deposit to be laid down, and even when the basalt beds cannot be seen quartz grit is present in the calcareous beds, as at Aldinga, Spring Creek, Shelford, Point Addis. There are of course places where the contact of the eocene with the underlying older rocks is seen and yet no limestone is found, as at Royal Park and Table Cape, but this in no way detracts from our contention for the shallow-water nature of the polyzoal limestone.

Professor Martin Duncan in speaking of our tertiary rocks says: "Pure limestone, except in the upper part of the series is rare; it contains there an abundance of polyzoa, and is a deep-sea deposit" (7, p. 286). In considering that part of this statement with which we are at present dealing, it must be borne in mind that ideas as to what constitutes a deep-sea deposit have greatly changed since Duncan wrote this, nearly thirty years ago. In the same volume of the Quarterly Journal his remarks show (pp. 54 and 70) that he applies the term deep-sea deposit to anything over ten fathoms, while for the great depths, then being for the first time explored, he would employ the term abyssal.

The organisms, of which the remains constitute the bulk of the rock, probably lived in places where, though the water might be many fathoms deep, yet strong currents prevailed, just as at present the strongly calcareous polyzoa exist in the greatest profusion with us at such places as Port Phillip Heads and the entrance to Western Port, where the tide-current runs most strongly and deposition of fine sediment cannot take place. Limestones of a similar nature are now forming apparently in the shallow waters in the neighbourhood of coral atolls as described by Dana (19, p. 121), and more especially by subsequent writers on the Lagoon of Funafuti. Professor T. W. Edgeworth David has told us orally that the floor of the lagoon is in many places covered with a thick deposit of foraminifera which are even now in parts being cemented into a solid rock. There is nothing then in the nature of the organisms, the remains of which build up our polyzoal limestone, and the foraminiferal limestone into which it in many places passes, which demands deep water for their growth, while the physical nature of the deposit, composed as it is of worn and broken fragments of considerable size, is clearly an indication of its formation in very shallow water or in places where strong currents run.

One of the most interesting points about the eocenes of the Aire, is the existence close together of two clearly distinct faunas. The fauna at the Otway section has been already dealt with by Messrs. Tate and Dennant, and its strong likeness to that of Aldinga has been noted by them (12, p. 113), and the Castle Cove section belongs to the same horizon. In contrast to the fauna of these beds is that displayed at Fishing

Point, which resembles that of Fyansford and Mornington, a resemblance which it is interesting to note, is already recorded by Mr. Reginald Murray in his Geology of Victoria, where he calls the beds about a mile inland, on the east side of the Aire, oligocene (11, p. 101), while he calls the other tertiary beds of the district, miocene (11, p. 103). Both sets are now generally regarded as eocene, though differences in the faunas exist.

As regards the relationships of the two sets of beds, the sections in this locality supply no conclusive evidence, since no junction is visible. The fact that the sections on the coast, near Castle Cove, are acutely folded, and show great variations in strike at the three localities, might be taken as evidence that the horizontal beds of Fishing Point unconformably overlie them. The Castle Cove series is undoubtedly the older, but it is more probable that the disturbance of the beds is merely a local phenomenon, and that the subsequently removed upper series partook in the folding, which ensued close to the flanks of the mesozoic. Whether a similar disturbance took place on the Otway side of the eocene is uncertain, as no clear outcrop of rock *in situ* is visible.

Evidence as to the succession of the beds then not being available here, we must look elsewhere for it, and we find it, as we have previously shown in the Moorabool Valley, where strata, with a strong Spring Creek facies, underlie the oligocene of the survey. We subsequently grouped the Aldingan and Otway beds with those of Spring Creek. Our opinions were objected to by Messrs. Tate and Dennant, who, in the same paper, arrived at the conclusion that the Aldingan and Otway beds represented an age anterior to that at which the Lower Muddy Creek beds were deposited, thus essentially agreeing with our previously published remarks.

The Newer Rocks.

There is nothing much as yet to be added to Wilkinson's remarks on the newer rocks as displayed in the Otway district. The pliocene of the survey, the greater part of which is now generally regarded as miocene, has not hitherto yielded any fossils in this locality, and is apparently ascribed to pliocene age on strati-

graphical evidence only. Wilkinson says (5, p. 25) that: "it occurs at intervals all round the Otway Coast Range, resting on the flanks of it, and at greater elevations than the older tertiary just described, though I have not observed it at a greater altitude than about 1,000 feet above the sea. South of the Dividing Range, we first meet with it at Point Bunbury, Apollo Bay; thence it continues westward to Moonlight Head, capping, more or less, the intervening ranges from one to six miles inland. From Moonlight Head it extends nearly as far west as Warrnambool, resting unconformably on the miocene (*i.e.*, of the survey, H. and P.!) On the north side of the Coast Range we have it, until it passes under the lava plains." He then describes the variations in the deposit in different localities, and mentions a curious coarse conglomerate, which occurs about ten miles up the Gellibrand, and which consists of granite, porphyry, mica-schist, quartzite, and very little true quartz. As far as is known there are no outcrops of ancient rocks in the Otway Ranges which could yield a conglomerate of this nature, in fact, its character as far as can be judged from this brief description, is such as we should expect to find in beds derived from the widely spread palæozoic glacial conglomerate of the southern parts of Australia, a fact to which one of us has previously drawn attention (20, p. 174).

With regard to the dune rock and the sand dunes, Wilkinson's descriptions are very full and accurate. He refers them to post pliocene age in his report and section. Duncan (7, p. 291) reproduces a part of this section, but in the legend omits the words, "post pliocene;" after "*b.* irregularly stratified yellow calcareous sandstones;" moreover, "*h.* brown sand," should read "blown sand." Wilkinson on page 23 of his report, speaks of the dune rock as "more recent tertiary sandstone," evidently regarding the post pliocene formation as a sub-division of the tertiary, a point in which he is of course in agreement with many recent geologists. In his letter to Aplin (4, p. 14), in speaking of these beds, he says: "the bed of lignite is of too limited extent to be of any economic value. It appears to be of very recent tertiary age, and the thick deposit of irregularly laminated calcareous sandstone which overlies it, I believe to be consolidated blown sand." In his report (5, p. 24) he says:

"This" (*i.e.*, 'post pliocene formation' H. and P!) is of no very great extent until we get to Warrnambool, which town is built on it. . . . South of a line drawn about a mile and three-quarters up the Parker River to a point about three-quarters of a mile up the Aire River, and the piece of land between that portion of the Aire Marsh through which the Ford River runs, and the coast as far west as Castle Cove, may be taken as the extent of this deposit at Cape Otway." Further particulars are given of the deposit as far west as Warrnambool, and for these as well as for remarks on the estuary deposits and sand dunes of the coast, reference must be made to his report.

SUMMARY.

The eocene beds of the Aire and Cape Otway occupy a small triangular area of about six square miles. For the greater part of their extent they are hidden by more recent deposits, which for the most part consist of estuarine or æolian beds so that the only outcrops are on the shore line or along the hills which bound the Aire Marsh. On their east and north-west borders they are hemmed in by the fresh-water mesozoic rocks of the Cape Otway series, which rise high above them as lofty hills, so that they perhaps owe their present position to faulting. The beds on the shore line near Cape Flinders, which are generally spoken of as the Cape Otway beds, and those in the neighbourhood of Castle Cove are older than those bordering on the Aire Marsh, the faunas of the two being in strong contrast. The occurrence of these two faunas so close together in the same neighbourhood shows that the differences between them are not due, as has been suggested, to geographical position, while as the lithological characters of the deposits show no striking contrasts, it cannot be that these differences are due to bathymetrical conditions. It follows then that the differences are dependent on difference in age, a point on which we have always insisted in our discussions on the sequence of our eocene strata. The disturbed condition of the deposits in the neighbourhood of Castle Cove, with their high dip and varying strike, possibly affords evidence that they underlie the horizontal beds displayed in the river sections, and if so this evidence is in accord with

that which we found at Maude and which led us to place the Spring Creek series beneath that of Mornington and Muddy Creek, this being the reverse of the reading of the old Geological Survey.

A discussion of the character of the polyzoal limestones leads us to the opinion that they are essentially a shallow water deposit, and not, as has been usually stated, the deep water representative of the argillaceous beds.

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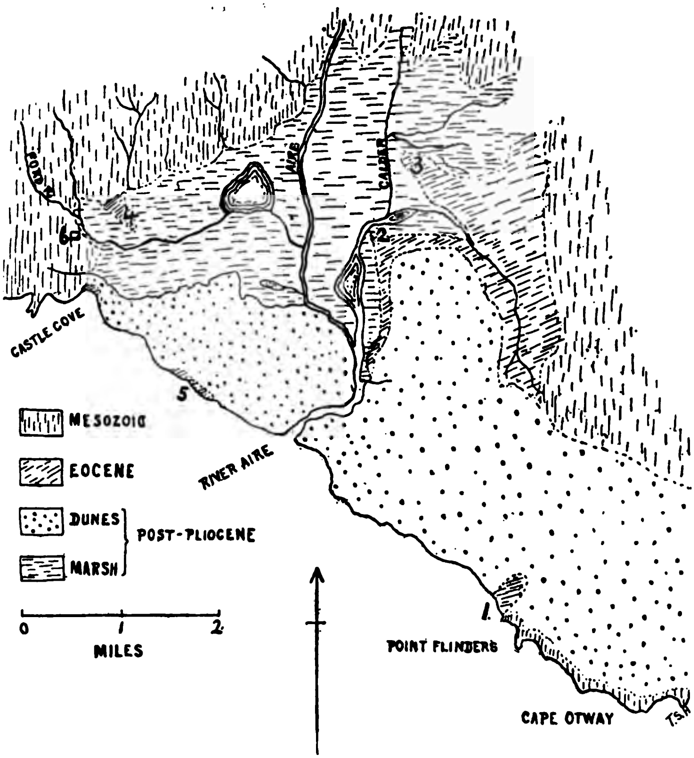
EXPLANATION OF MAP.

1. Otway Section.
2. Fishing Point.
3. Aire Limestones.
4. Spud Point.
5. Aire Coastal Sections.
6. Aire Cattle Station Homestead (Robinson's).



MAP SHOWING TERTIARY ROCKS NEAR CAPE OTWAY,

BASED ON WILKINSON'S MAP.

Hall, T. S. 1901

Royal Society of Victoria.

A SUGGESTED NOMENCLATURE FOR THE MARINE TERTIARY DEPOSITS OF SOUTHERN AUSTRALIA.

By T. S. HALL, M.A., and G. B. PRITCHARD.

(*Read 10th October, 1901*).

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ART. VIII.—*A Suggested Nomenclature for the Marine Tertiary Deposits of Southern Australia.*

BY T. S. HALL, M.A., AND G. B. PRITCHARD.

[Read 10th October, 1901.]

The confusion that has existed and still exists as to the age of the various members of the Tertiary series of Southern Australia makes it impossible for anyone who is not familiar with the history of the subject to understand what beds are referred to when the terms Eocene, Miocene, or Pliocene are used. It will probably be long before complete unanimity exists among workers in various parts of the globe as to the ages to which our subdivisions are to be referred, and meanwhile fossils are being described and recorded as Eocene or Miocene and the confusion is rapidly becoming worse. Moreover, with the progress of time the ideas of authors as to the age of certain beds change and their Eocene of to-day is not their Eocene of say ten years ago.

One familiar with even the outlines alone of our Tertiary Geology has only to glance at the brief notices which modern English text books give of our Cainozoic series to see confusion in the minds of geologists elsewhere. The fault lies at our own door and we should amend our ways and not pillory those who cannot understand us. We ourselves know without any difficulty what Duncan meant when he said "Miocene" and what M'Coy meant by Oligocene. We know what beds Professor Tate, Mr. Dennant and ourselves mean by these terms, but it is surely too much to ask anyone to so familiarize himself with the kaleidoscopic changes of our Tertiary controversy that he has to recollect the date of the paper he is reading and the particular views of the author at that date in order to remember the fauna associated with a newly described fossil.

Perhaps two examples will show the condition into which we have drifted and the urgent need of reform. There is a short section exposed near the hamlet of Beaumaris on the shores of Port Phillip Bay which, before closer settlement had filled in our

maps with locality names, was referred to as the Mordialloc, Cheltenham or Brighton beds. The age to which the beds are to be referred is the subject of very diverse views, as the following statement will show.

They were referred to:—

Older Pliocene	by McCoy	1875
Miocene	by Hall and Pritchard	1897
Miocene (?)	by Tate	1888
Oligocene (?)	by Tate	1899
Eocene	by Tate and Dennant	1893
Eocene	by Pritchard	1892

Similarly a series of beds at Spring Creek, south of Geelong, was held by M'Coy to range from Upper Miocene to Oligocene. Messrs. Tate and Dennant at one time considered the whole series Eocene, but at a later date Professor Tate referred it to Oligocene, while we are of opinion that the series as a whole is older than the Mornington series called Eocene by Messrs. Tate and Dennant as well as by ourselves.

Correlation of Australian strata with those of the Old World and with America is a task of great importance, and problems of interest connected with the place of origin of certain forms of life can only be solved when this task shall have been fulfilled. Hitherto the question of correlation has not received very detailed investigation at the hands of geologists of the northern hemisphere, for the question is one of extreme difficulty. The conclusions of Australian geologists have been provisionally accepted with a more or less open expression of doubt. But the time for this is passing away and we shall no longer be allowed to settle the question alone as best we can. American geologists are turning their attention to the Patagonian Tertiaries, which they assert have, as we should expect, an undoubted close relationship to ours. By the time scale they deduce they will judge the age of the mammalian fauna there, and as far as has yet been announced they will refer the marine beds to a younger age than we do. Probably if this be so we shall not give way without a struggle, but, with our present nomenclature, we must use terms which imply the acceptance of a theory. As a great amount of work for many years to come will be concerned with

the local correlation of our beds and the elaboration of our subdivisions it seems to us advisable to employ local names for the main subdivisions of our strata. This plan is of world-wide use, and by its adoption we should be making no retrograde step, but would be clearing the way for a detailed consideration of two problems, namely the correlations of our strata between themselves, and a correlation with strata elsewhere. If the main types have these names applied to them there will no longer be any need to say whose views one is following, as we need to now when speaking of certain beds as Eocene or Miocene. The important question as to the relative position of the different formations can be put on one side and need not be forced into consideration in every line of a paper dealing with some small local set of strata.

Recognising then the advisability of such a change, it remains to consider what are the principles which should actuate us in our choice. These seem to be few and simple. Firstly, any series of strata with a fauna differing appreciably in its constituents from others should receive a distinctive name. Secondly, the name should be taken from a locality where there is no chance of confusion between the contents of beds of distinct ages. Thirdly, we should not use names which are used in other parts of the world as names of formations. In the fourth place, it should be understood that the names given are given to a particular set of strata and are irrespective of the correctness or otherwise of the subsequent correlation of other beds with them.

Bearing these provisos in mind we may consider their application to our Tertiary strata and discuss the appropriateness of the following names which we suggest.

Werrikooian.

The Limestone Creek beds on the Glenelg River are in the Parish of Werrikoo, in the County of Follett. They have been referred to Pleistocene and to Pliocene. There is another Limestone Creek, near the head of the Murray, in Victoria, which yields Palaeozoic fossils, and a third in the County of Heytesbury, with Older Tertiary fossils.

Kalimnan.

The beds at Jimmy's Point, near the mouth of the Gippsland Lakes, are near the township of Kalimna. They were referred to Older Pliocene by Sir F. M'Coy, and by Mr. Dennant to Miocene. There are two other deposits in Victoria with rich faunas, which were considered Older Pliocene by M'Coy, namely, the Upper beds at Muddy Creek, near Hamilton, and the Beaumaris beds.

The former is called Miocene by Messrs. Tate and Dennant and ourselves, but, as it immediately overlies beds belonging to our older Tertiary series, a name received from this locality is unsuitable. The Beaumaris beds, again, are considered by ourselves to belong to the same series, but are quoted as older by Professor Tate, so that they are out of court.

Balcombian.

The clays and limestones of Balcombe's Bay contain another distinct fauna. The beds are sometimes spoken of as at Mornington, but the locality we give is more exact. The Lower Beds at Muddy Creek and the Orphanage Hill beds at Fyansford, near Geelong, are approximately equivalent to the Balcombe's Bay Beds, but the exact separation of the two sets of beds at Muddy Creek is not yet sufficiently clear, and a name from that locality would lead to confusion. The beds are called Eocene by Messrs. Tate and Dennant and ourselves. Sir F. M'Coy considered them Oligocene.

Jan Jucian.[1]

The section near Spring Creek, on the coast of Bass Strait, south of Geelong, is in the main in the Parish of Jan Juc, and its fauna differs greatly from that of Balcombe's Bay. The confusion about the age of these beds has been referred to above. The township near Spring Creek is called Torquay, but the use of this name in England renders another advisable. The older name for Torquay was Puebla, but the employment of this name, again, would lead to confusion with certain American strata.

1 The "c" is sounded like "k."

The name Jan Juc remains, and is referred to by M'Coy as the locality whence several of his fossils came.

Aldingan.

The term Aldingian has been used by Professor Tate in speaking of the section at Aldinga, but we should prefer the spelling we give. In the cliff sections, as described by Messrs. Tate and Dennant, "Miocene" overlies "Eocene," and the term Aldingian as used by them includes both sets of strata. If it be confined to the lower series only, it might perhaps be employed, though it violates the principle that a name should not be given from a locality where two distinct series are in contact. As we differ from the views of Messrs. Tate and Dennant on the question as to its equivalence or otherwise with the Spring Creek series, a type name may be thought advisable, for the present at any rate, though our own views are opposed to its use.

We should like once more to emphasise the point that the names we give are given in the first place to the beds displayed at the localities from which the names are derived, and we are thus able to fix a top and a bottom to each formation. There can be no doubt, except in our opinion in the case of Aldingan and Jan Jucian, of the distinctness of the faunas they typify.

CORRELATION.

We now come to consider the different sets of beds to be ranged under these names, for series of strata agreeing palæontologically must be grouped with them. About some there is at present unanimity of opinion, but in other cases diverse views are held. These points we shall indicate as far as we can, though, owing to the fact that no very detailed lists of comparable localities have been published by Messrs. Tate and Dennant, it is possible that their views may not always be correctly represented. The list we give is practically that published by one of us (G. B. P.) in the Report of the Brisbane Meeting of the Australasian Association for the Advancement of Science in 1895.

Werrikooian.

Limestone Creek.

Kalimnan.

Jimmy's Point, Gippsland. Upper beds of the Murray River Cliffs. Upper beds at Aldinga. Upper beds at Muddy Creek. Upper beds at Shelford. With these we would associate the Marine Sands of the Dry Creek and Croydon bores, South Australia, which were regarded by Prof. Tate as intermediate in age between the Limestone Creek and the Jimmy's Point beds. To this series we also refer the Upper beds at Beaumaris, which were correlated by Professor Tate with the Spring Creek series, the latter being, in our opinion, older than Balcombian.

Balcombian.

Balcombe's Bay and Grice's Creek, Mornington. Lake Connewarre. Southern Moorabool Valley. Upper beds at Maude. Altona Bay. Gellibrand. Camperdown. Murgheboluc. Shelford, lower beds. Bairnsdale. Corio Bay. Curlewis. Belmont. Fishing Point, Aire River.

Jan Jucian.

Spring Creek. Table Cape, Tasmania. Waurn Ponds. With these we include the lower beds at Maude, which Professor Tate and Mr. Dennant considered to show much closer relationship to the lower beds of Muddy Creek. We also refer to the same series the lower (*i.e.* "Eocene") beds at Aldinga, the Aire Coastal series and the Cape Otway beds. In the association of the Aldinga, Aire Coastal and Cape Otway beds together we are apparently in agreement with the views of Messrs. Tate and Dennant, but, as will be seen on referring to the earliest parts of this paper, their association with the Spring Creek and Table Cape series is strongly opposed to the view of the same authors. But as has been already pointed out the correctness of all the details of this correlation is not a necessary preliminary to the use of the terms suggested. It is open to those who differ to separate any of the members, and, where possible, to group them similarly under other appropriate names.

There still remains a number of localities which we have not grouped with any of the formations. With regard to these we consider the published evidence or our own knowledge to be insufficient for the expression of a definite opinion.

THE SEQUENCE AND AGE.

As an addendum to the main part of this note we may as well consider the different views which have existed as to the sequence and age of the beds to which we have attached names.

	M'Coy.	Tate & Dennant.	Hall & Pritchard.
Werrikooian	—	Pleistocene (Tate) Pliocene (Dennant)	Pliocene
Kalimnan	Older Pliocene	Miocene	Miocene
Balcombian	Oligocene	Eocene	Eocene
Jan Jucian	Miocene to Oligocene	Oligocene (?) (Tate) Eocene	Eocene
Aldingan	—	Eocene (in part)	Eocene (in part)

We thus have not only differences of opinion as to the ages of the beds but also as to the sequence of the component formations.

To put the matter in another way, the sequence according to the various authors would be—in descending order.

M'Coy.	Tate & Dennant.	Hall & Pritchard.
—	Werrikooian	Werrikooian
Kalimnan	Kalimnan	Kalimnan
Jan Jucian	Jan Jucian	Balcombian
Balcombian	Balcombian	Jan Jucian and
	Aldingan (in part)	Aldingan (in part)

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Royal Society of Victoria.

THE GEOLOGY OF THE BARWON ABOUT INVERLEIGH.

By T. S. HALL, M.A., and G. B. PRITCHARD.

(*Read 12th November, 1903*).

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Art. XVII.—*The Geology of the Barwon about Inverleigh.*

By T. S. HALL, M.A., and G. B. PRITCHARD.

(With Plate XXVI.).

[Read 12th November, 1903.]

Any references to the geology of the Barwon Valley between its junction with the Leigh and the Moorabool are but scanty. In 1889 we paid a brief visit to the junction of Native Hut Creek with the Barwon, and collected a few fossils, which were included in a Catalogue of Tertiary Fossils published by one of us in 1892 (1). A couple of years later the same author described Pinna cordata from near the same locality (2). In 1898 Messrs. Dennant and Mulder noted the occurrence of eocene clays at Inverleigh without, however, recording any fossils, and concluded that the deposit was continuous from that place northwards to the sections described by them about Shelford.

The general geological boundaries are shown on Everett's map, with perhaps as much exactness as the scale would allow, and are, as we understand from Mr. H. Herman, the result of a very hurried visit.

The township of Inverleigh is situated at the junction of the Leigh and the Barwon on an alluvial tongue in the broad valley cut by the two streams. To the west, south, and east the surface rocks are mainly basaltic, while to the north is a sandy plateau covered with the usual park-like growth of eucalyptus that this class of country generally supports in Southern Victoria. The surface of the lava plain drops rapidly from the northwards towards the foot of the Barrabool Hills, Elaine, twenty-two miles to the north, being 1300 feet above sea level, while the basalt escarpment west of Inverleigh is about 200 feet. From Inverleigh to Pollocksford the Barwon for the most part cuts its way through the lava to the underlying tertiaries, though about the junction of Native Hut and Bruce's Creeks it follows the

boundary between the basalt and the tertiary inliers to the north, which have never been covered by the flows. From Pollocksford to the junction of the Moorabool at Fyansford the river marks the geological boundary between basalt to the north, and the jurassic sandstones and other rocks, forming the Barrabool Hills, to the south.

Messrs. Dennant and Mulder have described the marine tertiary and associated beds of the Leigh in the paper quoted above, and have recognized about Shelford the occurrence of two sets of marine beds belonging to what they called eocene and miocene, and which we have suggested should be named Balcombian and Kalimnan. From a short distance above Shelford down to Inverleigh the left bank of the Leigh is bordered by a sandy plateau. The sands are in places cemented by iron oxide in their upper parts, and are succeeded in depth by slightly more argillaceous beds. On the opposite bank of the valley the upper beds have yielded Kalimnan fossils, and the lower ones Balcombian, and it seems probable that the same state of things should prevail on the left side of the valley, and that both sets of beds should be present, but the hill slopes are grass-covered for the most part and no Kalimnan fossils have been found as far as we are aware. The lower beds, where exposed, have yielded Balcombian forms; the most southerly, recorded by Messrs. Dennant and Mulder, being at "Farrell's" (Section 44, Parish of Carrah). Wherever the beds are exposed near river level, from here to Inverleigh, Balcombian fossils may be found, and were it not that Kalimnan species are yielded abundantly near Shelford, no hesitation would be felt in describing the whole inlier as Balcombian. The probability, however, is, as already indicated by Messrs. Dennant and Mulder, that there is a Kalimnan cover. On the eastern side of this area, where the Shelford road drops down into the Native Hut Creek Valley, the beds are very ferruginous, and we spent some hours searching in vain for fossils. Nor did we find any evidence one way or the other along the bush track from Teesdale to Shelford, while the deep road cutting, leading from the plateau to the Leigh Bridge higher up the valley than Inverleigh, was equally barren of result. We are, however, of the opinion, as already stated, that the superficial portion of the series should be regarded as Kalimnan, though fossil evidence is wanting.

The road from Shelford to Leigh Road (Bannockburn) traverses these sandy beds for the whole of its twelve miles of length, with the exception of a small patch of basalt at Teesdale, and a narrow flow, about a quarter of a mile wide, which passes down Stony Creek. To the southward this flow is continuous with that at the Inverleigh Racecourse, the low bluffs on the river bank east of Inverleigh, and so on across the Barwon south of this, till it merges in the wide basaltic area about the foot of Mount Pollock and the sandy plateau of Gnarwarre.

The sandy beds to the east of Stony Creek on the Teesdale-Bannockburn Road, are marked as younger tertiary on Everett's map; but there seems no good reason for the different colouration on the two sides of the Stony Creek coulée. This flow is only a very thin one where the Teesdale to Bannockburn Road crosses it, as evidenced by the fact that it usually supports a similar growth of trees to that which the sandy beds do, or, in other words, the roots pierce the basalt to reach the sands below. Besides this there are several bracken-covered patches of sand which rise slightly above the basalt which surrounds them. So far no fossil evidence of the Kalimnan age of the upper part of these beds has been found, though we have searched near Bannockburn and Murgheboluc. The underlying beds yield a Balcombian fauna at Murgheboluc and Native Hut Creek, as will be shown in the sequel; but we believe the superficial beds to belong to the younger series, though, it must be admitted, on very slight evidence.

The present paper deals more particularly with the sections of the Balcombian beds displayed along the course of the Barwon from Inverleigh to Pollocksford. These occur on the faces of the gorge cut by the stream, and are not indicated on Everett's map, with the exception of the one below Murgheboluc. Even had they been noticed the small scale of the map would have prevented their indication.

Inverleigh.

For about a mile and a half above the bridge on the main road the river flows close along the foot of the plateau to the north of the township, with the result that numerous small outcrops of

Balcombian beds occur close to water level. A couple of hundred yards or so above the bridge there is a good exposure along the river, which can only be worked when the water is about summer level. There is another exposure at about the same distance below the bridge. As in all the outcrops about here the beds are practically horizontal, we have not kept the fossils separate. The strata consist of light grey sandy clays, and the fossils are in a good state of preservation. Among the more interesting finds were several specimens of Poroleda lanceolata, hitherto known only from the Gellibrand and Grice's Creek.

From the bridge for about a mile to the south-east the Leigh and the Barwon, which unites with it, meander through sandy alluvial flats, and then plunge into a shallow gorge about forty feet deep, cut into basalt, which occupies the river bed. A succession of rapids follows for a mile and a quarter when another alluvial flat is met, where the river receives the Native Hut Creek coming down from the north.

Native Hut Creek.

There is a fair exposure at the junction of the two streams, and a much better one about a mile and a half up the creek. At this upper section the beds are again sandy, with sheets of sandy limestone a few feet in thickness interstratified, and becoming ferruginous as we ascend. There is a considerable amount of salt in the beds, and brackish springs or soakages occur at various points, and the fossils are apt to become destroyed by efflorescing salt, unless washed immediately after collection.

A fine tooth of Carcharodon megalodon, five and a quarter inches in height, was obtained here, as well as a large nautilus, eight inches in diameter, and Cypraea gigas. Fragments of large shells are not uncommon, but fossils are only sparingly scattered through the sandy matrix. Pinna cordata, Prit., came from the junction of Native Hut Creek and the Barwon.

After the confluence of the two streams the Barwon turns sharply to the south, and describes a U-shaped loop about three miles in length. There are a few exposures apparently of Balcombian beds beneath the basalt cover, but we saw no fossils. At the road marked between Allotments 20A and 20B,

Parish of Gnarwarre, the basalt comes down to river level, and about 200 yards below this columnar basalt occupies the stream bed. Near the western boundary of Allotment 21 a short gully comes in from the south, and has brought down a small amount of coarse quartz conglomerate, derived apparently from some beds underlying the basalt. Soon after this the river skirts high bank in Sections II.A and II.B of Murgheboluc, and good exposures are displayed.

Murgheboluc II.B.

Close to the junction of Allotments II.A and II.B we find at river level five feet of grey clays passing up into fawn sandy clays, and then into sands. There are several concretionary limestone bands present, some of which are rich in foraminifera, and might almost be called Operculina limestone, so plentiful are examples of this genus. The cliff is about 70 or 80 feet high, and is capped by basalt. The base of the cliff is somewhat masked by fallen debris, but a few yards further on the river runs close past its foot, and an easily worked section is exposed.

The beds as a whole resemble the others described, being grey sandy clays, with well preserved fossils in its lower part, though they have disappeared higher up the bank. There is an area of about 200 acres on the right bank of the river, from which the basalt has been denuded, and the boundary between the sandy older tertiary and the alluvium cannot be clearly drawn.

From here to the Murgheboluc flat we noted only a couple of exposures; one at river level in Section III., A and B, of Murgheboluc, seemed fairly rich, and we saw Cypraea eximia, and a few other typical forms. The river now touches the southern border of what we may call the Bruce's Creek tertiary area, which extends from here northward to about Lethbridge, the probable age of the superfical beds of which we have previously alluded to. A large amount of denudation has taken place, and on the northern or left bank of the river there is nearly a square mile of alluvial flat intersected by a few deserted river channels, and there is a smaller similar area on the south side of the stream. The whole quadrangular area is hemmed by steep cliffs about 100 feet in height, the river entering and leaving by comparatively narrow gorges at the two southern angles.

Bruce's Creek Junction.

A good section is displayed on the river bank in Section IV. A, Murgheboluc. The composition of the beds, as before, is grey, sandy clays, and a fair number of fossils were obtained, including a tooth of Cestracion, n.sp., and, as is usual in sandy beds, the fossils have disappeared from the higher parts of the cliffs.

From here to Pollocksford, a little over two and a half miles in a straight line, the river gorge is narrow, and its sides are masked by basalt from the plateau above. Here and there indications of the underlying tertiaries are to be seen in places; but, even where sandy cliffs occur under the basalt, as in Section IV. C, which is inaccessible, or in Section V. B, no fossils were obtained. Just above Pollocksford an outcrop of yellow sandy clay was found, forty-five feet above the river level, and then, a hundred yards below this, columnar-basalt occupies the river bed for nearly half a mile.

Between Pollocksford and Fyansford the river skirts the jurassics, which rise to over 400 feet to the south, and is hemmed in on the north by basalt. We defer any discussion of this part of the country to a later paper.

The Age of the Marine Beds (Barwonian Series).

An examination of the lists of fossils given shows that the beds examined from Inverleigh to Murgheboluc are almost identical with those of Red Hill, near Shelford, and of Orphanage Hill, Fyansford. Lithologically the whole series, from Red Hill and thence down the Barwon through Inverleigh, Murgheboluc and so on to Fyansford (Orphanage Hill), are very similar, though at the latter place there is far less sand, and the beds are really grey marls.

In the paper in which we proposed the names Balcombian and Janjukian we indicated the existence of certain beds which undoubtedly belonged to the older series comprised under these two names, which are clearly distinct from the younger Kalimnan, but which from the smallness of the collections available, we did not care to refer definitely to either Balcombian or Janjukian. In other words, the palaeontological differences between Balcombian and Janjukian series, though of importance, are not

nearly so marked as between them and the Kalimnan. On these grounds we think it advisable that a name should be given which will comprise both Balcombian and Janjukian. The former series is extensively developed in the Barwon basin, and the latter at its typical exposure at Spring Creek, south of Geelong, is not far from the borders of the same basin, so that the name Barwonian is suggested.

No geographical name that can be proposed is of course free from objection on the grounds that other beds are present in the area taken as typical; but it seems advisable that a local name should be employed, and the present seems a satisfactory one.

The Basalt Plains.

There are no points of eruption in the immediate neighbourhood which can be pointed to as the probable sources of the thin, but wide-reaching, lava flows of the plains. Mount Pollock, a few miles south of Inverleigh, is merely a lava-capped outlier, a fact which Everett's map seems to indicate, for it is not marked as a point of eruption. We hope at some future time to discuss the characters of the country about here which are not made clear by our preliminary examinations. The river course when crossing the lava-covered plains is usually trenched to a depth of about 100 feet about Murgheboluc, but about Native Hut Creek and on the Barwon above Inverleigh the depth is less. Owing to constant masking of the steep slopes by basaltic soil, the thickness of the flows is rarely determinable with exactness, but as shown by the frequent presence of basalt *in situ* in the river bed, and at others by the outcrop of sandy beds at a high level, the old surface was very uneven.

The boundaries of the basalt are roughly shown on Everett's map.

The Younger Beds.

Apart from the alluvium of the present valleys there is a series of extensive sheets of sands and gravels which in many places overlie the basalt. The country between Winchelsea and Inverleigh is shown on Everett's map as covered by a uniform basalt sheet, whereas, between the outlier known as Mount

Pollock and the river Barwon on the west, the country is covered with quartz sand, which on some of the river cliffs is seen to be about thirty feet in thickness, reposing on basalt, into which the river has cut its way for another thirty feet. One travels for miles along the Winchelsea Road without seeing a stone wall, and as the plains are devoid of timber, stone would have been used did it outcrop. Following this sandy country to the northward, we find it on the left bank of the Barwon also, between Inverleigh and Native Hut Creek, extending from the river itself northwards beyond the Geelong Road. On the east of Native Hut Creek a strip about twenty feet in thickness and half a mile in length from north to south is crossed by the main road. Evidence of its former extension to the eastward is afforded by scattered quartz pebbles on the basalt plateau east of Murgheboluc. Here the material is evidently derived from the sandy tertiaries north of the Barwon, which were not covered by the flows of lava, and which in many places still rise above its level. In the neighbourhood of Inverleigh itself it is at times impossible to separate this deposit from the sandy alluvium of the river flats and the Balcombian beds, which are also sandy. We think it better to regard the ground on which Inverleigh is built as alluvium rather than as Balcombian, as some of the river cliff sections show very characteristic, thin, irregularly bedded structure quite distinct from the even bedding of the marine beds.

Some of the hillocks west of the township which gradually rise to the level of the basalt of the western plains are doubtless Balcombian, for it underlies the whole district between the ordovician on the north, and the jurassic on the south. The high level alluvium on the basalt points probably to a time when the drainage system was different from what it is now, and when the Barwon and the Leigh possibly found their way to the sea by passing along the south side of the Barrabools, the flow along the long reach of the Barwon south of Inverleigh, and reaching to near Winchelsea, being reversed.

List of Fossils.

Name of Fossil.	Inverleigh.	Native Hut Creek.	Murgheboluc.	Barwon R. Bruce's Creek Junction.
	1	2	3	4
Lamellibranchiata.				
Ostrea hyotis, Linnaeus	.	2	?3	?4
Dimya dissimilis, Tate	1	2	3	4
Pecten murrayanus, Tate	.	2	.	4
„ foulcheri, T. Woods	.	2	.	.
„ eyrei, Tate	1	.	.	4
„ sturtianus, Tate	.	2	3	4
„ yahliensis, T. Woods	.	.	.	4
Amussium zitteli, Hutton	1	2	.	4
Hinnites corioensis, McCoy	.	.	.	4
Lima bassi, T. Woods	1	.	3	4
„ linguliformis, Tate	.	.	.	4
Limatula jeffreysiana, Tate	1	.	3	4
Limea transenna, Tate	.	.	3	.
Spondylus pseudoradula, McCoy	1	2	3	4
Meleagrina crassicardia, Tate	.	.	3	4
Pinna cordata, Pritchard	.	2	.	4
Septifer fenestratus, Tate	1	2	3	4
Modiolaria balcombei, Pritchard	1	.	.	.
Nucula tenisoni, Pritchard	1	2	3	4
„ atkinsoni, Johnston	1	2	.	4
Leda vagans, Tate	1	2	3	4
„ huttoni, T. Woods	.	2	.	.
„ apiculata, Tate	1	.	3	4
„ praelonga, Tate	1	.	.	.
Sarepta obolella, Tate	1	2	3	4
Poroleda lanceolata, Tate	1	.	.	4
Limopsis belcheri, Adams and Reeve	1	2	3	4
„ morningtonensis, Pritchard	1	.	.	.
Glycimeris maccoyi, Johnston	1	2	3	4
Barbatia celleporacea, Tate	1	2	.	4
„ crustata, Tate	1	2	3	.
Plagiarca cainozoica, Tate	1	2	3	4
Cucullaea corioensis, McCoy	1	2	.	4
Trigonia tubulifera, Tate	1	2	.	.
Crassatellites communis, Tate	1	2	3	4
„ dennanti, Tate	.	.	.	4
Cardita polynema, Tate	1	2	3	4
„ delicatula, Tate	1	2	3	4
„ scabrosa, Tate	.	2	.	4
Chama lamellifera, T. Woods	1	2	3	4
Cardium cuculloides, Tate	.	.	.	4
Protocardium hemimeris, Tate	1	2	3	4
„ antisemigranulatum, McCoy	.	2	.	.

LIST OF FOSSILS (*continued*).

Name of Fossil.	Inverleigh.	Native Hut Creek.	Murgheboluc.	Barwon R. Bruce's Creek Junction.
	1	2	3	4
Chione cainozoica, T. Woods	1	2	3	4
„ dimorphophylla, Tate	.	.	.	4
Meretrix eburnea, Tate	1	2	3	4
Dosinia densilineata, Pritchard	1	.	.	.
Tellina cainozoica, T. Woods	1	?2	.	4
Semele krauseana, Tate	1	.	3	4
Myodora tenuilirata, Tate	1	2	3	.
Capistrocardia fragilis, Tate	1	.	.	.
Corbula ephamilla, Tate	1	2	.	4
„ pixidata, Tate	1	2	3	4
Gastropoda.				
Murex lophoessus, Tate	1	2	3	4
„ rhysus, Tate	1	2	.	.
„ velificus, Tate	1	2	3	4
„ eyrei, Tate	1	.	3	4
„ basicinctus, Tate	.	.	3	4
Typhis acanthopterus, Tate	1	2	3	4
„ evaricosus, Tate	1	.	.	.
Trophon asperulus, Tate	.	2	3	4
Rapana aculeata, Tate	.	.	.	4
Argobuccinum maccoyi, Pritchard	1	2	3	4
Lotorium woodsi, Tate	1	2	3	4
„ cyphus, Tate	1	.	.	4
„ tortirostre, Tate	1	2	.	.
„ pratti, T. Woods	.	2	.	.
„ tumulosum, Tate	.	.	3	.
„ protensum, Tate	.	.	.	4
„ annectans, Tate	.	.	.	4
Fusus senticosus, Tate	1	.	3	4
„ simulans, Tate	.	2	.	.
Latirofusus hexagonalis, Tate	1	.	.	4
„ exilis, Tate	1	2	.	4
Clavella bulbodes, Tate	.	2	3	4
Siphonalia longirostris, Tate	1	.	.	.
„ tatei, Cossmann	1	.	.	.
Solutofusus carinatus, Pritchard	.	2	.	.
Fasciolaria cryptoploca, Tate	1	.	3	4
„ cristata, Tate	.	2	.	4
Latirus interlineatus, Tate	1	2	.	.
„ succinctus, T. Woods	.	2	3	4
„ subundulosus, Tate	.	2	3	4
Euthria ino, T. Woods	1	2	3	4
Phos tardicrescens, Tate	1	.	3	.
Loxotaphrus variciferus, Tate	.	.	3	4

LIST OF FOSSILS (*continued*).

Name of Fossil.	Inverleigh.	Native Hut Creek.	Murgheboluc.	Barwon R. Bruce's Creek Junction.
	1	2	3	4
Nassa tatei, T. Woods	.	2	.	.
Voluta hannafordi, McCoy	1	2	.	4
„ antiscalaris, McCoy	1	2	3	4
„ strophodon, McCoy	.	2	3	4
„ ancilloides, Tate	1	.	3	4
„ maccoyi, T. Woods	1	.	.	.
„ costellifera, Tate	1	.	.	4
„ weldii, T. Woods	1	.	.	.
Volutoconus conoidea, Tate	1	.	.	?4
Lyria harpularia, Tate	.	2	.	4
Mitra alokiza, T. Woods	1	2	.	.
„ leptalaea, Tate	1	2	.	.
„ atractoides, Tate	1	2	.	4
„ othone, T. Woods	.	2	.	.
„ ligata, Tate	.	2	3	.
Marginella propinqua, Tate	1	2	3	4
„ micula, Tate	1	2	.	.
„ inermis, Tate	1	.	.	.
„ wentworthi, T. Woods	.	2	3	.
„ septemplicata, Tate	.	2	.	.
Ancilla semilaevis, T. Woods	1	.	3	.
„ pseudaustralis, Tate	.	.	.	4
Harpa spirata, Tate	1	.	.	.
Columbella funiculata, T. Woods	.	2	.	.
Cancellaria varicifera, T. Woods	1	2	3	4
„ gradata, Tate	.	2	.	.
Terebra leptospira, Tate	?1	.	.	4
Columbarium acanthostephes, Tate	1	2	.	4
„ craspedotum, Tate	.	2	.	4
„ foliaceum, Tate	1	2	.	4
Pleurotoma murndaliana, T. Woods	1	2	3	4
„ trilirata, Harris	1	2	.	4
„ septemlirata, Harris	.	2	3	4
„ optata, Harris	1	2	.	.
„ clarae, T. Woods	.	2	3	.
Bathytoma rhomboidalis, T. Woods	1	2	3	4
Drillia oblongula, Harris	.	.	3	.
Clathurella bidens, T. Woods	1	.	.	4
Buchozia hemiothone, T. Woods	1	2	3	.
Bela sculptilis, Tate	1	.	.	4
Conus dennanti. Tate	1	2	.	4
„ heterospira, Tate	.	2	.	4
„ cuspidatus, Tate	1	2	.	4
„ ligatus, Tate	.	2	.	.
„ ptychodermis, Tate	.	2	.	.

LIST OF FOSSILS (*continued*).

Name of Fossil.	Inverleigh.	Native Hut Creek.	Murghebeluc.	Barwon R. Bruce's Creek Junction.
	I	2	3	4
Cypraea gigas, McCoy - -	1	2	.	4
„ eximia, Sowerby - -	1	2	.	4
„ contusa, McCoy - -	1	2	.	4
„ leptorhyncha, McCoy -	1	2	.	4
„ brachypyga, Tate - -	1	.	.	.
„ pyrulata, Tate - -	1	.	3	4
„ sphaerodoma var., Tate -	.	.	.	4
Trivia avellanoides, McCoy - -	1	2	3	4
Cassis exigua, T. Woods - -	1	.	.	.
Cassidea sufflata, T. Woods - -	.	2	3	.
Morio gradata, Tate - - -	.	2	.	4
Natica hamiltonensis, T. Woods -	1	2	3	4
„ polita, T. Woods - -	1	2	3	4
„ subnoae, Tate - - -	1	2	3	.
Crepidula unguiformis, Lamarck -	.	.	3	.
Xenophora tatei, Harris - -	1	2	3	4
Solarium acutum, T. Woods - -	.	2	.	.
Scala pleiophylla, Tate - -	.	2	.	.
Turritella platyspira, Tate - -	1	2	3	4
„ acricula, Tate - -	1	2	3	4
„ murrayana, Tate - -	.	.	.	4
„ tristira, Tate - -	.	2	.	.
Tenagodes occlusus, T. Woods -	1	2	3	4
Thylacodes conohelix, T. Woods -	.	2	.	.
Eulima danae, T. Woods - -	1	.	3	4
Niso psila, T. Woods - - -	.	2	3	.
Mathilda transenna, T. Woods -	1	2	.	.
Cerithium apheles, T. Woods -	1	2	3	4
Newtoniella cribarioides, T. Woods -	1	2	.	4
Triforis wilkinsoni, T. Woods -	1	2	.	.
„ planata, T. Woods -	.	2	.	4
„ sulcata, T. Woods -	.	2	.	.
Collonia parvula, T. Woods - -	.	2	.	.
Fissurellidaea malleata, Tate -	.	2	3	4
Subemarginula occlusa, Harris -	1	2	3	4
Emarginula wannonensis, Harris -	1	.	3	.
Scaphander tenuis, Harris - -	1	.	.	4
Bulinella exigua, T. Woods - -	1	.	.	.
„ aratula, Cossmann - -	1	2	3	4
„ cuneopsis, Cossmann -	1	.	3	.
Actaeon distinguendus, Cossmann -	.	2	.	.
Umbraculum australe, Harris -	.	.	3	.
Dentalium aratum, Tate - -	1	2	.	.
„ mantelli, Zittel - -	1	2	3	4
„ subfissura, Tate - -	1	2	3	4
Vaginella eligmostoma, Tate -	.	2	.	.

LIST OF FOSSILS (*continued*).

Name of Fossil.	Inverleigh.	Native Hut Creek.	Murgheboluc.	Barwon R. Bruce's Creek Junction.
	1	2	3	4
Cephalopoda.				
Nautilus, n. sp.- - - -	1	2	3	4
Brachiopoda.				
Magellania garibaldiana, Davidson -	1	2	3	4
„ corioensis, McCoy -	.	.	3	4
Terebratulina scoulari, Tate -	.	.	3	.
Terebratula tateana, Johnston -	.	2	3	4
Zoantharia				
Placotrochus deltoideus, Duncan -	1	2	3	4
„ elongatus, Duncan -	1	2	3	4
Flabellum victoriae, Duncan -	1	2	3	4
„ gambierense, Duncan -	1	2	3	4
Balanophyllia australiensis, Duncan	1	.	3	.
Bathyactis lens, Duncan - -	1	2	.	4
Ceratotrochus halli, Dennant -	1	.	.	.
Notophyllia gracilis, Dennant -	1	.	.	.
Conosmilia anomala, Duncan -	1	.	.	.
„ striata, Dennant - -	1	.	.	.
Pisces				
Carcharodon megalodon, Agassiz -	.	2	.	.
Cestracion, n. sp. - - -	.	.	.	4

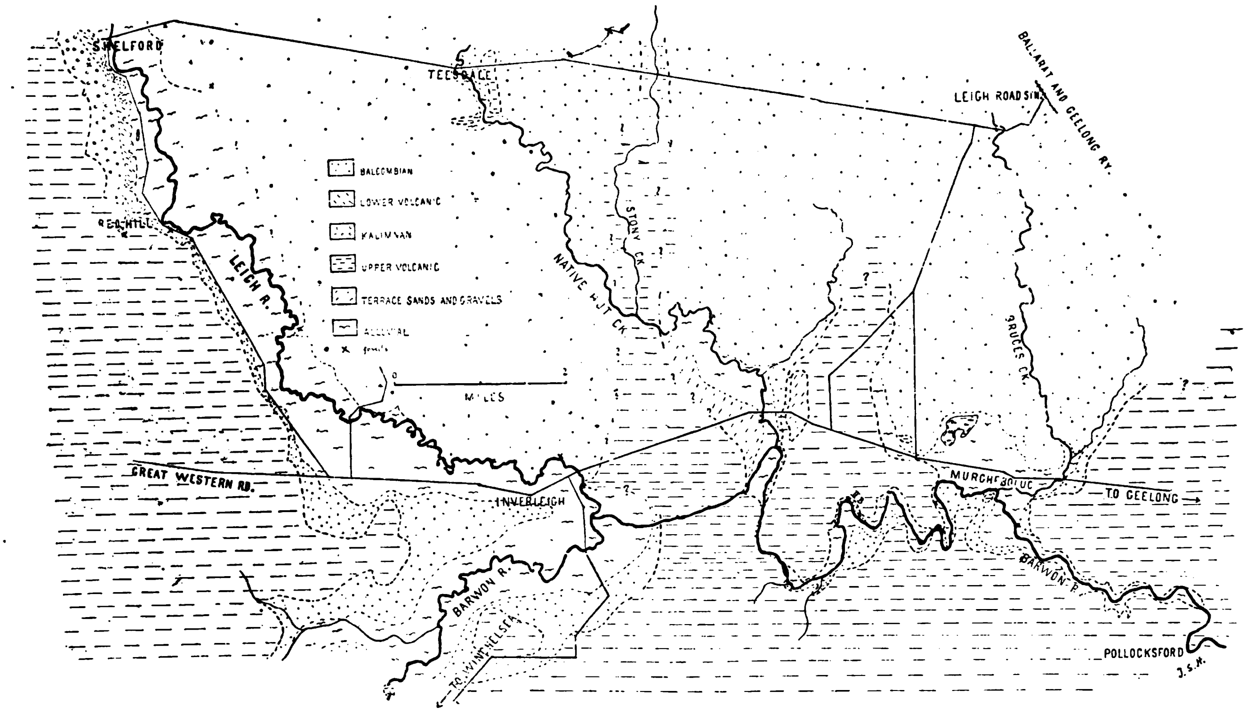
SUMMARY.

Pisces - - - - - - -	2
Cephalopoda - - - - - -	1
Gastropoda - - - - -	124
Lamellibranchiata - - -	53
Brachiopoda - - - - - -	4
Zoantharia - - - . -	10
	194 species.

Inverleigh - - - - - - -	125 species.
Native Hut Creek - - - -	127 „
Murgheboluc - - - - - -	89 „
Barwon River, Bruce's Creek Junction -	122 „

LITERATURE.

1. *Pritchard (G. B.)*—Remarks on the Tertiaries of Australia, together with Catalogue of Fossils. Adelaide, Govt. Printer, 1892.
2. *Pritchard (G. B.)*—Contributions to the Palæontology of the Older Tertiary of Victoria. Proc. Roy. Soc. Vic., 1894 (1895), p. 228.
3. *Dennant (J.)* and *Mulder (J. F.)*—The Geology of the Lower Leigh Valley. Proc. Roy. Soc. Vic., vol. ix., 1898, p. 56.



Geological Map of the Inverleigh District.